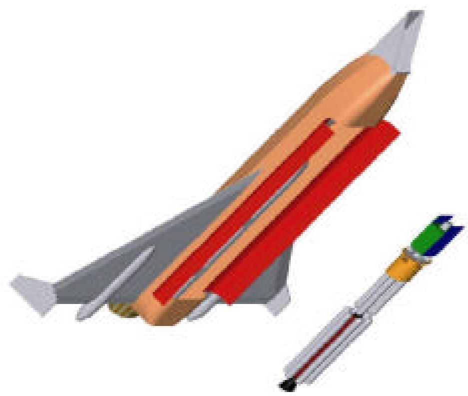

RESPONSIVE ACCESS, SMALL CARGO, & AFFORDABLE LAUNCH (RASCAL) DEMONSTRATION PROGRAM

PHASE I

PROGRAM SOLICITATION 02-02

December 10, 2001

Defense Advanced Research Projects Agency
DARPA/TTO
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1 Introduction

The Defense Advanced Research Projects Agency (DARPA) is pleased to offer you the opportunity to respond to the Responsive Access, Small Cargo, and Affordable Launch (RASCAL) Demonstration program solicitation. As you explore this solicitation, we believe you will appreciate this unique opportunity to work in partnership with DARPA to design, build, and demonstrate the technical feasibility of a RASCAL system which can effectively and affordably conduct 21st century Low Cost Access to Space missions.

The RASCAL system will consist of two major elements: a Recoverable Launch Vehicle (RLV) and an Expendable Rocket Vehicle (ERV). Since a primary objective of the effort is to create a low cost means of placing small satellites in Low Earth Orbit (LEO), DARPA believes contractors wishing to participate in the Phase I study should be in a position to design the entire system and address its life-cycle costs. Respondents having a capability in only the RLV, ERV, or some other aspect of the system, should seek partners so the study can effectively deal with the entire system. The program described in this solicitation begins with an initial study phase (Phase I) followed by two additional phases that will demonstrate the technical viability, costs, and operational aspects of selected system approaches.

1.1 Motivation

The United States military forces currently lack adequate capabilities to provide on demand space-based communications, imaging and sensing, and signal intelligence in support of tactical theater commanders. Current supporting assets are assigned to higher-level commanders and it is difficult and inefficient to reassign orbits and inclinations to the desired theater in a timely fashion. The United States military forces also lack the ability to quickly launch space assets. This deficiency is in large part a consequence of the lack of low-cost launch vehicles and methods capable of providing timely response to rapidly changing events and other time-critical military activity. The United States military forces and the space industry have no dedicated launch capability for small payloads under 100 kilograms. At this scale, payloads are forced to find "piggy back" launch opportunities with larger payloads. Often launch opportunities do not exist, or are so restrictive in nature as to not be viable for these small payloads. Technology trends indicated that payload sizes are decreasing and the potential of LEO constellations of small satellites is being explored. As a result, there is a need for launch of small payloads that continues to go un-serviced. Figure 1-1 The Approximate Distribution of DoD Payloads Launched Annually illustrates this need.

This new generation of smaller launch vehicles will provide a cost effective mechanism to enable many critical space missions. Some of the more important missions for this new launch system will be:

1. Launch components in support of space deterrence and defense capabilities.
2. Launch specialized tactical satellites that are design to support a theater of operation.
3. Launch components and supplies for an orbital re-supply and servicing capability.
4. Launch space components of a missile defense system.
5. Flight qualify new technologies.
6. Support numerous governmental and commercial small satellite payloads.

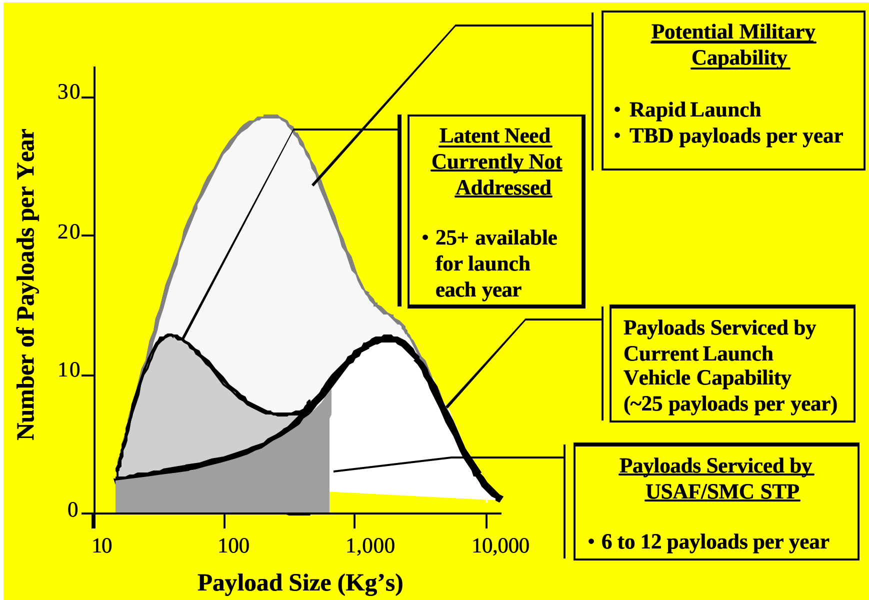

Figure 1-1 The Approximate Distribution of DoD Payloads Launched Annually

With this trend towards smaller, more functional satellites, the advent of small cheap ground stations, and the wide application of the Internet, constellations of small LEO satellites have a potential for being a revolutionary capability that is projected to increase the number of small satellites as compared to the existing paradigm of large space systems. At the very least, there is a growing potential for niche applications in telecommunications, sensor data collection, on-orbit servicing, on-orbit re-supply, and navigation markets for LEO constellations that are synergistic with latent military need and requirements. One of the main obstacles to the implementation of small LEO constellations is the lack of responsive and affordable launch to orbit. Despite this obstacle, the worldwide trend in the number, and distribution, of payloads to orbit is shifting dramatically towards smaller satellites.

DARPA believes new propulsion technologies can enable a new launch system architecture and concept of operations that can remedy this deficiency. This new system would be capable of placing dedicated tactical satellites in orbit to meet increased, short-term, and task specific demands, supplying consumables to military satellite constellations to enhance maneuvering capabilities of orbital assets and to extend satellite life span; and offering substantial economies over existing launch systems for placing entire networks of military satellites into space for long-term, strategic purposes.

Technologies developed in this program will also enable affordable launch of a variety of other small payloads within DARPA and the military services. For example, the Air Force's Space Test Program has an extensive backlog of experiments currently being warehoused for lack of a satisfactory, low-cost launch vehicle. In addition, a number of non-military governmental agencies such as NASA, DOE, NOAA, and FAA have requirements for placing small satellites and other payloads into space as well. In large part, these agencies rely on scarce launch opportunities to piggyback in combination with other larger satellite missions. Universities are confronted with a similar dilemma in that experiments developed for flight are unable to find affordable rides to orbit. Significant speculation has been offered that commercial opportunities in the areas of communication, navigation, and imaging and sensing would rapidly propagate if a reliable and affordable means of placing small commercial satellites into LEO were developed.

1.2 Vision

DARPA's vision for the RASCAL Program is to design and develop a dedicated orbital insertion capability to LEO to meet the unfulfilled military and commercial small satellite market needs. The program will develop a rapid, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements.

The RASCAL program seeks to exploit the design and operational freedoms of not requiring a fixed infrastructure at dedicated launch sites and enable a new paradigm in launch vehicle affordability while maintaining the performance and safety of traditional launch systems. Our vision is that the RASCAL system will be more reliable than traditional systems in delivering functional satellites to their proper orbits. To achieve both low cost and high reliability, RASCAL must be kept as simple as possible and based on processes for which variation can be well controlled. In our vision, this launch system will require airplane like maintenance, can be stored for extended periods of time prior to payload integration, and will be capable of autonomous operations outside of normal government range safety control with minimal human involvement.

The vision of the future for space access includes RASCAL systems as an integral part of the military force structure. From ordinary airfields, RASCAL systems will be able to support rapid insertion missions at any time, into any inclination, for any theater. RASCAL systems will be globally deployable and safely operate over populated areas and in controlled air space.

Achieving acceptable economic performance will be a major goal in the development of the RASCAL system. The viability and long-term success of this system will depend on keeping the contractor's life cycle cost (CLCC) and the cost per launch as low as possible with available technology. Our goal is to make the launch price comparable to larger, existing launch vehicles in terms of cost per kilogram of payload delivered to orbit. This is approximately $750,000 for a 75-kg payload to LEO. In determining the cost of a launch for RASCAL, the cost will include the recurring RLV and ERV costs and peculiar GSE and initial spares costs, associated with both RLVs and ELVs and the related Operating and Support (O&S) costs of both the RLV and ELVs.[1]

Total CLCC for the RASCAL system will be fundamentally different from that of traditional launch vehicles. The RASCAL program will minimize development risk and cost by evolving the reusable elements of the system from aircraft technology. Aircraft require less assembly and integration per mission. The total maintenance and "touch labor" required for military tactical missions and commercial applications are relatively low compared to historical costs of missile systems. The vision for RASCAL's reusable elements is to evolve from this technology experience rather then to invent revolutionary reusable launch vehicle approaches. Depending on the results of the affordability trades, the RLV could be a modified existing airframe or use a newly developed vehicle, and could be manned or unmanned. The use of a new vehicle offers possible reductions in O&S costs because the Reliability and Maintainability of new equipment is much improved relative to legacy aircraft. Studies done in connection with the Joint Strike Fighter program have also shown that dramatic reductions in O&S costs are possible with the application of Prognostics and Health Management technology for the prediction and isolation of failures. The government has also invested in low cost rocket concepts for several decades and expects to see the fruits of this investment applied to the expendable elements of the RASCAL.

RASCAL will enable the implementation of a unique Concept of Operations (CONOPS) and provide the opportunity for significant O&S cost savings over conventional ground launch systems. With the advent of GPS and miniaturized inertial sensors, the possibility of reducing the dependence of RASCAL operations upon government ranges is expected. The aircraft element of RASCAL should provide the system enough mission radius to operate from a variety of airfields and utilize cleared commercial airspace. Range safety functions and information are expected to be flexible for a variety of operational scenarios. The vision for RASCAL is to eliminate the requirement

[1] Since investment costs of both RLVs and ELVs are dependent on the numbers of systems being procured, the cost analysis will be based on Ground Rules and Assumptions (GR&A) that will be detailed after award of the phase 1 contracts. Current thinking is that development costs associated with non-recurring engineering and modification of older aircraft or design and fabrication of new prototype aircraft for test and demonstration purposes will not be included in the computation. The $750,000 cost per launch will, however, be based on a procurement of sufficient operational RLVs and ELVs to support 50 launches per year and the prorated annual O&S costs of both RLVs and ELVs. The primary purpose of the GR&A is to assure some level of comparability of the solutions offered by the participating contractors, as well as to provide a benchmark of cost savings as compared to legacy launch systems.

for the system to operate from a dedicated government launch range and to minimize the associated range support costs.

1.3 Program Philosophy

In this solicitation you are being asked to “think out of the box” and propose your own unique collaborative design methodologies, modeling and simulation tools, processes, capabilities, concepts, and innovative teaming arrangements to reduce the cost of product development, manufacturing, and operations and support. We will not provide traditional specifications and a statement of work. Instead, we will describe our objectives in this solicitation and provide guidance on preparing your response. DARPA will set the bounds of the problem and allow the selected contractor(s) to perform system analyses, trade studies and risk reduction activities to develop and refine a RASCAL Demonstration System (RDS) that provides the best value solution to the program objectives. The products of the RASCAL Demonstration program must enable decision-makers to determine whether it is technically feasible and fiscally prudent to continue development and production of a RASCAL system. The goal of this program is to develop, demonstrate and adequately produce enough assets to ensure two LEO satellite insertions with an operationally representative RASCAL system that has the potential to be rapidly refined and transitioned after Phase III, to commercial or military applications. Funding, schedule and technology risk will scope the level of fidelity in the demonstration.

We are not interested in a program that follows a traditional ground launch configuration and marginally meets the objectives. The design must be able to grow as technology is discovered and applied. The offeror is expected to judiciously exploit cutting edge “out of the box” designs while incorporating the best practices from the space and missile industries and the commercial sector along with lessons learned from past manned and unmanned aircraft systems.

The RASCAL program is built upon the following premises:

1. DARPA wants a RASCAL system capable of delivering a 75 Kg satellite payload into LEO on short notice at a cost not exceeding $750,000 per launch (exclusive of the payload cost). The defining LEO is a sun synchronous 500 KM altitude orbit.
2. DARPA will fund the study, analysis, design, fabrication and test of a RASCAL Demonstration System (RDS) that can adequately prove the RASCAL concept and validate the projected operational system cost.
3. Depending on funding, schedule and technological constraints, the ultimate RASCAL Operational System (ROS) may not reflect substantial engineering changes when compared to the RDS system.
4. The ROS should be capable of providing launches at a cost not exceeding $750,000 per launch for either government or commercial users.

Our real interest in the Phase I studies is to identify a RASCAL concept, through system trade studies, which offers the promise of a technical success and which promises to achieve the target costs for the ROS.

The offeror shall treat cost as a priority and make intelligent choices so that the ultimate RASCAL design reflects a balance between capability and affordability without compromising the operational goals of the ROS. The solicitation for Phases II and III will challenge the offeror to tell the Government what can be delivered with high reliability for an “affordable” price.

2 Program Description

2.1 Program Goal

The goal of DARPA's RASCAL Demonstration program is to develop and demonstrate the technical feasibility for a low cost responsive space access system dedicated to small payloads. The objective is to effectively and affordably meet the 21st century's small satellite insertion needs with acceptable technological risk. This three-phase program will design, develop, integrate, and demonstrate the critical technologies pertaining to an operational RASCAL system. The critical technology areas are: augmented high powered short cycle propulsion systems, RLV exo-atmospheric control and ERV staging, low cost expendable rocket vehicle (ERV), and low cost RLV.

2.2 System Demonstration Objectives

In order to achieve a leap in affordable launch capabilities, DARPA sets the following aggressive system demonstration objectives in descending order of priority:

- Demonstrate mission turn-around time within a 24 hour period after payload arrival
- Deliver payload of 75 Kg in to a 500 Km sun synchronous orbit
- Demonstrate, through a credible cost estimating model, that recurring launch costs can converge on the goal of $750,000 per launch 75 KG payload for the RASCAL Operating System [2] (Note: not including the cost of the satellite payload and as mentioned in Section 1.2, 3.4)
- Validate ability to operate from a 2500 meter runway with minimal peculiar support equipment (PSE) and independent of test ranges for telemetry and tracking support
- Demonstrate exo-atmospheric staging using a MIPCC engine configuration
- Demonstrate adequate vibration/load isolation between the satellite payload and the rocket vehicle
- Demonstrate mission scramble capability within an hour of notification, after ERV integration.
- Demonstrate ability to loiter and adjust flight path to accommodate dynamic mission planning

During Phase I, the contractors must develop two sets of cost estimates (section 3.4). The first deals with the estimated costs of developing the RDS system. The second deals with the estimated costs of the ROS, which might result from a successful demonstration of the RDS system. The goal is to minimize the engineering changes between RDS and ROS.

The critical affordability assumptions and technologies will be validated, to the extent possible, through concept and process demonstrations. We believe the ability to strike a balance between the recurring and nonrecurring program cost will be crucial to the success of the program. DARPA encourages contractors to maximize use of Commercial Off The Shelf (COTS) or Military Off The Shelf (MOTS) components and manufacturing processes whenever possible to achieve the development and mission cost objectives.

Your ability to define operational capability and affordability requirements, and then use them as a filter to select the critical technologies to be matured and validated during the demonstration, is vital to the success of this program. Defining the critical cost drivers and associated critical processes early in system development is a key component of

[2] Or $10,000 per KG

this program. The outcome of this demonstration is to quickly and affordably transition advanced technologies and reduce the acquisition cycle for new systems.

2.3 Mission Description

RASCAL system characteristics will determine, in large part, the utility it will provide the military. The "RA" in RASCAL stands for responsive access; that is, the ability to launch payloads rapidly and routinely with the flexibility to adapt to changing needs. This is the critical capability a RASCAL system must demonstrate. The mental model being used by DARPA is an extension of military aircraft operations. Aircraft operations are a good example of operations that are flexible and adaptable towards evolving and emerging missions. Aircraft operations are also affordable, in part, because an extensive and highly developed infrastructure and technology base exist. The development of a successful RASCAL system will use aircraft operations as a strong influence in its concept of operations and will take as much advantage as possible of existing aircraft infrastructure and technology.

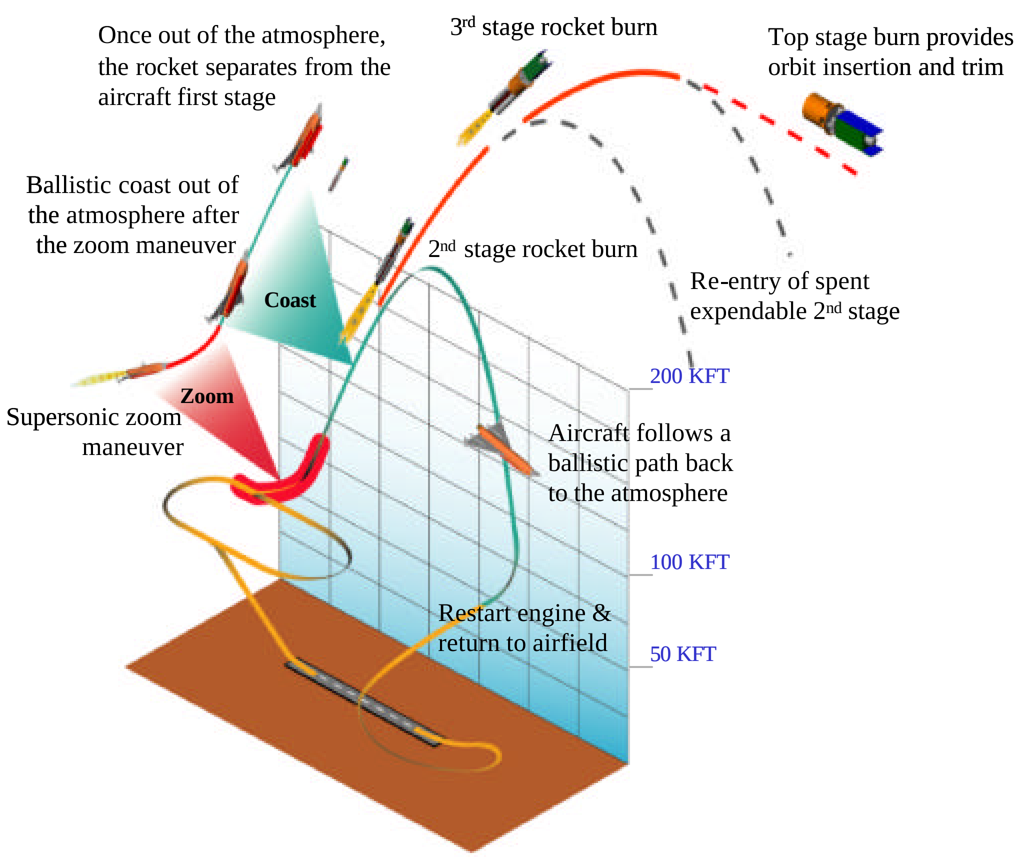

Figure 2-1 Notional RASCAL System Concept of Operations

Figure 2-1 Notional RASCAL System Concept of Operations (CONOPS) above describes a notional CONOPS for a RASCAL system that meets DARPA's intent. In this notional RASCAL system, the first stage vehicle is a reusable aircraft powered by a turbojet engine with a Mass Injected Pre-Compressor Cooled (MIPCC) installation. The upper portion of the system is an expendable rocket. The satellite payload is carried internal to the reusable aircraft and is deployed, with the rocket, once the proper exo-atmospheric staging conditions are achieved.

With the RASCAL system assembled (i.e., rocket and payload installed in the reusable aircraft) and after all the appropriate mission planning and air space clearances have been obtained, a typical mission is able to begin. The

RASCAL system, operating out of a typical military airfield and to the maximum extent possible, normal aircraft maintenance and support equipment have been used to prepare the system for its mission. The most dramatic special equipment and material required is related to the oxidizer required for the rocket vehicle and perhaps the MIPCC subsystem. Since the aircraft is powered by a conventional turbojet engine, it is able to propel itself from the flight line to the end of the runway. Once the vehicle has been cleared for takeoff, the vehicle accelerates and lifts off in a manner similar to typical military jet aircraft. Its liftoff performance, speed, distance, abort options, and overall performance are typical, with few special characteristics or abnormal considerations. The aircraft climbs out on a flight path towards the mission's planned launch point. After climbing to a typical cruising altitude, the vehicle cruises at subsonic velocity to a launch point, accelerates to launch speed and altitude, launches the ERV and returns to the airfield. Once at the launch site, the vehicle is able to loiter on station in a hold pattern and wait for the launch commitment. The vehicle is able to loiter until it has to divert to an airfield or is refueled in flight.

Once the launch command has been received, the aircraft maneuvers to the proper launch azimuth and begins the boost maneuver that will place it upon a sub-orbital ballistic trajectory out of the atmosphere. Boost propulsion is achieved with MIPCC of the turbojet engine. Once the required boost conditions have been achieved, the engine is shut down and allowed to windmill. The aircraft continues to coast farther out of the atmosphere following its ballistic path. After the aerodynamic loads have fallen sufficiently, the rocket and payload are ejected from the aircraft. The rocket and payload hold their attitude after they have been ejected with their own active attitude control system. The aircraft translates away from the rocket in order to achieve a safe distance before the rocket ignites and continues its journey to orbit with the payload.

As the rocket continues toward orbit, the aircraft continues along the ballistic trajectory back to the atmosphere. The aircraft maintains a high angle of attack as it reenters the atmosphere in order to create drag and to minimize aero-thermal heating on the airframe. Eventually it will slow down and arrive at an altitude and speed favorable for restarting the engine. The aircraft will fly back to the airfield of origin and land in a manner typical of a military aircraft.

The rocket, in the meantime, has continued accelerating to orbital velocity. The rocket's guidance, navigation and control functions are provided by the avionics contained in the top stage rocket and will guide itself to the desired target orbit. Some payloads will desire a somewhat higher orbit or will require a greater insertion accuracy than can be achieved with the control of the main boosters. In these cases, the top stage will be able to maneuver the payload to a higher orbit, or trim the orbit insertion conditions. This capability allows the rocket and the RASCAL system to adapt to a variety of mission requirements. The multiple stage configurations, once staged, will reenter the atmosphere and impact the earth.

Once back at base, the aircraft can be inspected, repaired, maintained and made available for another mission within 24 hours. Like normal aircraft operations, the RASCAL system will have graceful mission abort options and scenarios. In the majority of these options, the rocket and the payload will be returned to base, able to fly another day. The RASCAL system will be comparable in safety and reliability as current tactical fighters and expendable systems for the RLV and ERV segments, respectively. The government will consider both manned and unmanned systems based on development and CLCC tradeoffs.

In the notional mission above, little detail was given about the interaction between the RASCAL system and range safety organizations, mission control centers and mission planning functions. There are a number of innovations that can be made in this area. At the small scale of the RASCAL system, these functions can dominate the recurring costs of a launch if performed in traditional ways. The Government is looking for innovations that will perform the same required functions, but in a manner that is more cost effective. Successful approaches will not require the "standing armies" of traditional range support organizations and will make maximum use of GPS, Micro Electronic Machinery INS, Internet, and automation technologies. The RASCAL RLV technology should exhibit safety and reliability comparable to existing tactical fighters.

For a complete vision of affordable access to space, it must also acknowledge the indirect costs of launch to the payload organization: those costs driven by constraints, environments, and verification processes imposed by the launch system. We are challenging offerors to develop a transportation system that greatly reduces such indirect costs from those typical of existing launch systems. RASCAL should provide a "soft ride" (relatively free of potentially damaging vibration) that is predictable and dependable. Doing so will simplify payload testing and pre-launch analysis, enable lighter payload structures, and enable better chances that the satellite will be functional once it attains its orbit. The most obvious way to provide a soft ride is to decouple the launch vehicle's dynamics from those of the payload through use of a loads-isolating mounting system, similar in concept to the suspension system for an automobile. We believe such a mounting system is feasible and affordable if incorporated early enough in RASCAL design (Details in section 8.2).

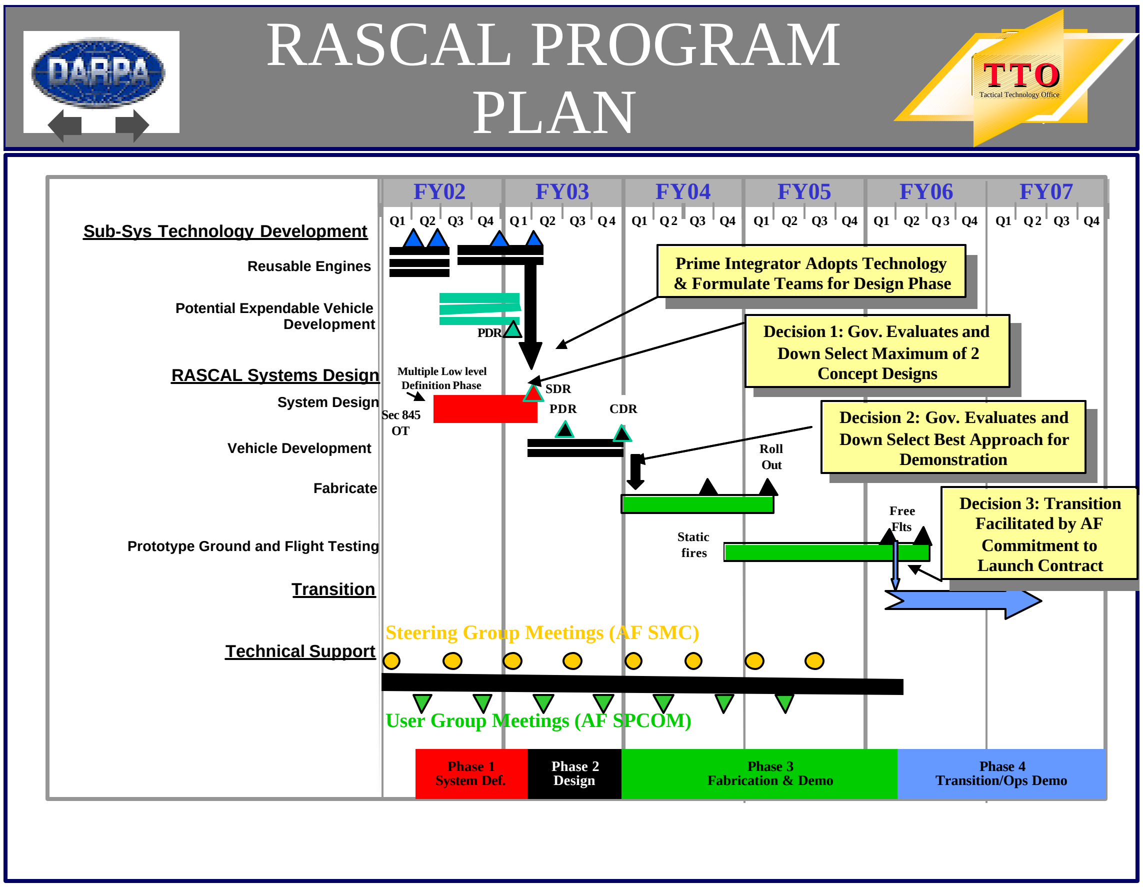

Figure 2-2 RASCAL Acquisition Strategy

2.4 Program Plan

The RASCAL acquisition strategy is shown in Figure 2-2 RASCAL Acquisition Strategy. The goal of this strategy is to provide the information necessary at the completion of each phase to enable government decision-makers to determine whether it is technically feasible and fiscally prudent to further develop a RASCAL system.

The RASCAL program is divided into three phases. During Phase I, DARPA will award multiple, 9 month, Other Transaction for Prototype agreements for a MINIMUM of: System Level Design of a RASCAL Demonstration System (RDS), a refined Technology Development and Assessment Plan (TDAP), and a contractor life cycle cost (CLCC) model. Funding availability and value of proposals will drive the number of awards in Phase I. Phase I proposal value is not dictated in this solicitation, product and value will be evaluated. The RDS will be designed to mature and validate the integrated set of critical technologies required for an operational system. At the conclusion of Phase I, DARPA will determine whether to down select to Phase II from the Phase I participants, or terminate the program. The decision will be based on a thorough assessment of the results of Phase I as well as the extent to which the contractors' proposed Phase II program will provide significant value. If the government decides to proceed, a maximum of two Phase I contractors will be selected to complete the RDS critical design, conduct risk reduction testing, update the TDAP and continue to refine the CLCC model. At the conclusion of Phase II, once again, DARPA will determine whether to down select to Phase III or terminate the program. Similarly, this decision will be based on a thorough assessment of the results of Phase II as well as the extent to which the contractors' proposed Phase III program will provide significant value. If the government decides to proceed, a single Phase II contractor will be selected to fabricate the RDS, integrate the critical technologies, continue risk reduction activities, and conduct flight tests.

Towards the end of Phases I and II, a solicitation update will be provided with proposals due one month prior to Phase completion. This will allow the program to transition between phases without any delay or disruption. Phase III will culminate with two successful payload insertions into LEO. Phase III is scheduled to be completed by the end of FY06.

The program plan calls for the development of a refined TDAP during Phase I and a RASCAL Production Transition Plan (RPTP) during Phase II. Together these plans will provide an integrated roadmap for all activities necessary to meet the RASCAL program goals. The updated TDAP will detail all the Phase II and III risk reduction efforts, subsystem and component verification tests, vehicle checkout and flight safety activities, critical technology evaluations and assessments, and flight demonstration of the RDS. The RPTP will address any operational evaluations, RLV and ERV technology and manufacturing process development, maturation, transition, and/or risk reduction activities which are necessary to continue development of a RASCAL system up to the point of a decision to enter into acquisition. The management team will coordinate both plans with industry and the DoD to ensure maximum advantage is taken of any leverage opportunities, and scarce research and development dollars are focused on supporting the acquisition strategy. Both plans will be continually updated during the entire demonstration program to reflect emerging results. Desired transition scenarios are to use residual demonstration vehicles and provide a commercially or military operated launch service or to continue with additional operational testing.

2.5 Management Approach

DARPA is responsible for overall management of the RASCAL Demonstration, including technical direction, acquisition, and security. The PM is responsible for implementing a streamlined approach to program management and transition. Major tenets of that approach include: close cooperation between government and contractor teams, small staffs, abbreviated oversight, face-to-face communication, real-time decision making, and short, direct lines of authority.

As required, the PM will bring on expert technical advisors from outside organizations. DARPA will charter the RASCAL Demonstration Technical Support Team (TST) to meet that responsibility. The TST has a mandate to draw upon the full spectrum of technical expertise within USAF, Navy, and NASA organizations. The TST includes a team lead and individual focal points for: Program Management, System Engineering Integration and Test Segment, RLV Airframe Segment, Mission Control/Planning Segment, ERV Segment, Software and Avionics Segment, Supportability Segment, and Turbine Propulsion Segment.

2.6 Other Transactions Authority

The RASCAL Demonstration program will utilize DARPA's Other Agreements Authority (Other Transactions for Prototypes Section 845/804), which allows the offeror to be creative in designing the system and in the selection of the management framework which best suits the proposed technical and management approach. The government will share information and data throughout the program. However, the data will always be advisory, not directive in nature, and offered as a way to foster better communications on the program. Our intent is to provide the best possible insight into what the government thinks while minimizing oversight. To this end, the government will focus on accurately defining what they want and letting the offeror determine how best to provide it. Government oversight will be provided through the same management framework proposed by the offeror.

The government will allow the offeror to use either commercial or DoD streamlined processes, reporting and management practices. The use of Other Agreement Authority requires compliance with applicable laws but allows the latitude to depart from acquisition specific laws, FARs, and DoD practices where it makes sense. The offeror should take full advantage of this latitude to propose innovative/revolutionary approaches to team building. The resulting offeror proposal must clearly demonstrate a robust method to assure and control costs, quality, reliability, system engineering, program schedule, system design, and test planning and execution.

Commercial, industrial, and corporate specifications and standards should be used in lieu of military specifications and standards where appropriate. Military specifications and standards, if needed, should be used as guides, with any modifications, tailoring or partial application described. A rigorous formal process should be employed to design, verify and implement software.

All proposals will be evaluated by a formal Government source selection evaluation board (SSEB) established to review all responses to the solicitations. The government reserves the right to conduct a rolling down select from the end of Phase I to Phase II, Phase II to Phase III based on contractors' performance. Rules and criteria for the rolling down select process will be included in the Phase II and III Solicitation provided prior to the end of each phase.

In order to broaden the technology and industrial base available for meeting Department of Defense needs, conditions have been put forth on the use of Section 845 Other Transaction for Prototype authority by the recent enactment of the National Defense Authorization Act for fiscal year 2001. Section 803 of the National Defense Authorization Act for FY2001 (Public Law 106-398) became law on 30 October 2000 and modifies DARPA's authority to use Other Transactions for Prototypes. For proposals submitted under this solicitation there must be either at least one nontraditional defense contractor participating to a significant extent in the prototype project; or, if there is no nontraditional defense contractor participating to a significant extent, at least one of the following circumstances must exist: at least one third of the total cost of the prototype project is to be paid with funds provided by parties to the transaction other than the Federal Government; or, the senior procurement executive determines that exceptional circumstances justify the use of a transaction that provides for innovative business arrangements or structures that would not be feasible or appropriate under a contract. There is no definition for "significant extent" as in a "Nontraditional defense contractor participating to a significant extent in the prototype project." The Government has discretion in determining the level of "significant extent." Some factors may include:

a) criticality of the technology being contributed
b) role of the non-traditional defense contractor(s) in the design process
c) value of the effort being proposed in comparison to the potential cost share value requirement

Because the evaluation is subjective, it carries with it some risk to the proposing team that the Government will not recognize the value; therefore, offerors are requested to identify in their agreement addendum the applicable Section 803 condition with explanation, which qualifies them to receive an 845 award. The entire amendment to the Authorization Act is available for your convenience at <http://www.darpa.mil/cmo> under "Breaking News" and includes the definition of a nontraditional defense contractor.

Teams composed of members with complementary areas of expertise are strongly encouraged. To this end, DARPA invites all interested offerors to provide capability statements to assist with teaming arrangements. In light of the new Section 803 language for other transactions for prototypes conditions, offerors are requested to specify on their capability statements whether or not they qualify as a nontraditional defense contractor. Capability statements will be posted on the web with the solicitation. Specific information content, communications, networking, and team formation are the sole responsibilities of the participants. DARPA does not endorse the information and organizations posted.

2.7 Funding

The government anticipates having $88M available to fund the Phase I, II and III agreements (all awards). It is anticipated that multiple awards will be let for the Phase I effort. DARPA also anticipates a funding level of approximately $5M total for Phase I. DARPA also anticipates extending the Phase I OT agreement to cover subsequent Phases. Offerors are encouraged to propose innovative, value added use of this acquisition mechanism. We expect the offerors to provide realistic cost proposal for best achieving the program objectives within the stated budget and schedule. The Government test range cost will be funded outside of the stated funding above and should not be included in the proposal

3 Phase I Statement of Objectives

This section outlines the Government's objectives for Phase I, Studies, Analyses and System Design for the RASCAL Demonstration program. The primary objectives of Phase I are to establish the requirements, analyze the CONOPS, conduct trade studies, and generate a system design and CLCC model. These are necessary to demonstrate that the development and flight-testing of a RASCAL Demonstrator System (RDS) provides sufficient value to the government to justify investing in Phase II and III. The results from a successful Phase I program will convince the Government that: (1) The RASCAL system will be an effective and affordable option for orbit insertion missions, (2) the Phase II proposal can accomplish the risk reduction and the detailed critical design objectives within the funding constraints, (3) a TDAP can be developed to better understand scope of Phase III, and (4) the design will meet the mission cost by evaluating the contractor life cycle cost model.

3.1 Overview

The contractor will implement a complete systems engineering process to achieve the Phase I objectives. The contractor shall perform system requirements analyses, design trades, CONOPS analyses and CLLC assessments, and refine a TDAP. The major Phase I activities represent a progressive refinement of the contractor's RASCAL Proposal Concept, to identification of critical technologies, and to development of the RDS System Level Design. The contractor will update the TDAP that identifies Phase II risk reduction efforts, critical technology evaluations and assessments, Phase III subsystem and component verification tests, vehicle checkout and flight safety activities, and flight demonstration details of the RDS.

System requirements and CONOPS analyses, trade studies, and the RDS engineering design shall be conducted in accordance with DARPA's System Demonstration Objectives (Section 2.2), the Mission Description (Section 2.3), and the Phase I objectives described in this section. All studies and analyses performed during this phase shall be documented and accomplished in accordance with the proposed Technology Development and Assessment Plan (TDAP), section 4.4.3. The contractor will be responsible for considering all subsystems associated with a RASCAL system, including the Reusable Launch Vehicle, Expendable Rocket Vehicle, Mission Planning and Control Segment, and Supportability to a level of detail necessary to justify their RDS, CLCC analyses, program plan, and TDAP. All Phase I analyses, trade studies, and risk reduction activities will be documented.

We anticipate a RDS defined in sufficient detail to provide the Government team with adequate information in selecting the integrated set of critical technologies that will undergo initial risk reduction during Phase II and further development and demonstration during Phase III as part of the updated TDAP. The RDS design must also be sufficiently detailed to allow identification of technology maturation or risk/cost reduction activities identified in the contractor's TDAP.

Phase I results will serve as the foundation and provide a roadmap for achieving the RASCAL Demonstration vision and objectives during Phase II and III. The RDS designs, refined TDAP, and other results of the Phase I efforts will serve, in part, as evaluation factors for award of Phase II efforts.

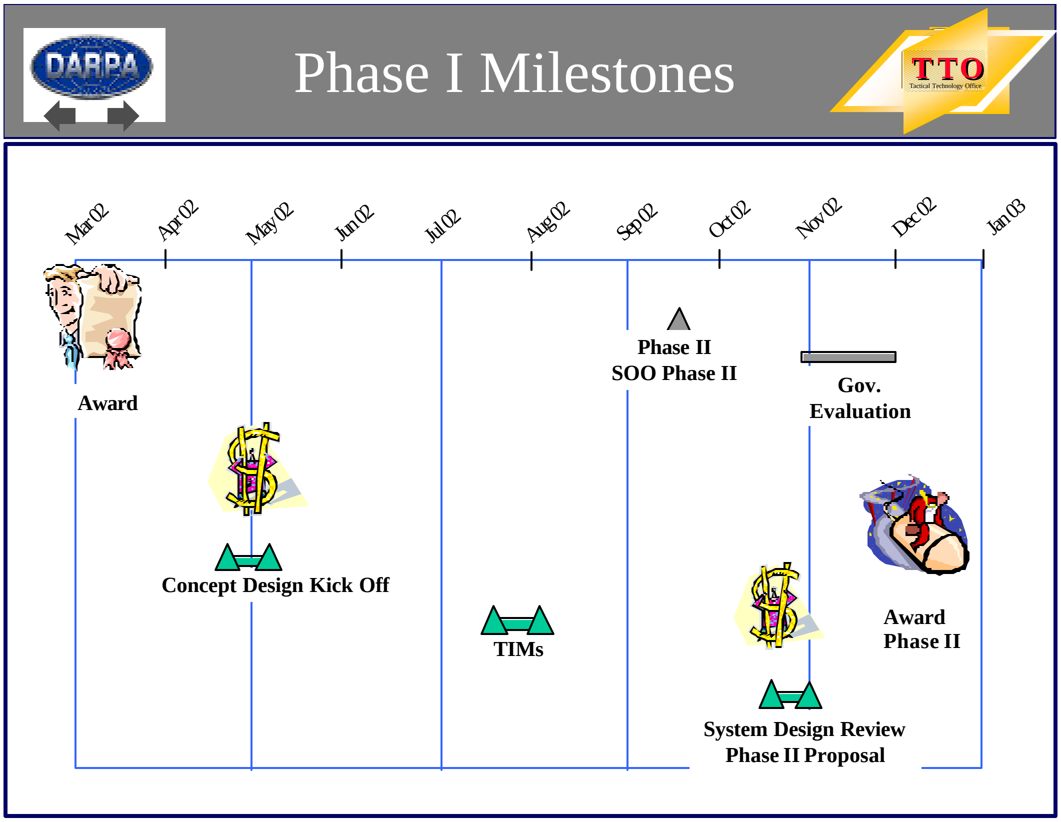

Figure 3-1 Phase I Milestones

3.2 Milestones

The government envisions three Phase I milestones. At a minimum, at each milestone the contractor must provide the following information and meet the exit criteria:

- Milestone 1 – Concept Design Kick Off - within 2 Months After Award
    - Information presented:
        - A preferred concept design
        - Results of system requirements analyses, initial design trades, and refinement of CONOPS
        - Methodology of RDS and ROS life cycle cost analysis

    - Minimum Exit Criteria:
        - Next level of system design detail and CONOPS trade space described in Section 3.3 explored at the conceptual level
        - Identification of Key trades / analysis
        - Key RDS and ROS cost model components and assumptions defined[3]

- Milestone 2 – System Design Review - after 7 1/2 Months after award
    - Information presented:
        - Final results of system requirements definition
        - Results of design trades and CONOPS studies

[3] Evaluate launch costs and the methodology for development of the cost estimates for each cost element required to exercise the model

- Preliminary listing of critical and enabling technologies
- Demonstrator System Design Review (SDR)
- Results of Draft ROS launch cost model development and cost element assessments
- TDAP
- Review of Phase I results

♦ Minimum Exit Criteria: Information presented demonstrates a;
- CONOPS trades described in Section 3.3 fully explored
- Demonstrator System Level design:
  - which addresses the critical and enabling technologies and
  - with all functional interface requirements established,
  - sufficient level of effectiveness and affordability as measured against the figures of merit
- Sufficient level of validation in the LCC model[4]
- Updated TDAP which clearly articulates key features of all the Phase II risk reduction efforts, critical technology evaluations and assessments, and Phase III subsystem and component verification, vehicle check-out and flight safety, and flight demonstrations of the RDS,
- Satisfactory completion and information presented clearly articulates all the results of Task Description Document (TDD) activities
- RDS SDR demonstrated sufficient merit to warrant proceeding to the next phase

- Milestone 3 – Report submittal
  ♦ Information submitted:
  - Final report
  - Any updates of the SDR presentation with annotated notes on CD Rom

3.3 System Analyses, Design Trades and CONOPS Analysis

There is a wide spectrum of launch vehicle approaches. After the RASCAL objectives and goals are applied, the spectrum of solutions narrows considerably, but the number of approaches is still significant. DARPA is not interested in following architectural approaches that have already been demonstrated. These concepts have been fully studied and do not promise the growth in capability DARPA believes is possible. It must be remembered that DARPA is about the discovery and development of revolutionary concepts and technology. The interpretation of DARPA's mission for RASCAL is that DARPA is investing in an architectural approach that is innovative and promises clear evolutionary paths towards even greater improvements in performance, capability, flexibility and cost. To put it another way, DARPA is not interested in investing in improving and refining existing launch approaches like expendable vertical launch multi-stage rockets, or subsonic air-launched expendable rockets. Although an improvement or refinement in these existing approaches may meet the RASCAL immediate objectives and goals in some fashion, DARPA does not believe they can meet them robustly or with any significant growth capability.

The contractor will concurrently conduct a series of system requirements and CONOPS analyses and system design trades that progressively refine their initial concept into a final RDS design. The specifics of the Program Goals (Section 2.2) should serve as bounds for the RDS and are tradable except for the following in no particular priority:

1) Mission cost goal
2) Reusable Horizontal takeoff and Horizontal landing first stage vehicle,
3) First stage propulsion using mass injected pre-compressor cooled (MIPCC) Turbojet engines
   a. MIPCC turbojet engines must be considered by the contractor, trade studies that depart from MIPCC for the first-stage boost propulsion system are allowed,

[4] Address cost estimates created to exercise the model, results obtained and the sensitivity of total launch costs to values of the key variables. Suitable documentation will be required to lend credibility to the cost estimates. [In subsequent phases of the RDS, the contractor will be expected to refine the launch cost analysis.]

b. The contractor is responsible for researching MIPCC patented design implications,

4) Exo-atmospheric staging between RLV and upper stage vehicle,
5) Internal carriage of the satellite payload to the exo-atmospheric staging point,
6) Payload vibration isolation.

These required features are intended to infuse new technology and new system approaches into the considered solution space for RASCAL.

Within this design space, the contractor shall conduct comprehensive trades and analyses to identify the system performance required to accomplish the orbital insertion missions described in the mission description and identify the corresponding suite of critical technologies for achieving that performance. All trades shall consider the RLV and ERV supportability segment including the concept to reduce maintenance, logistics, and integration timeline. During these studies the contractor should exploit the freedom to incorporate design philosophies from the munitions and aircraft industries and the commercial sector.

3.3.1 CONOPS

The contractor shall perform the trades, analyses, and modeling and simulation to define the RASCAL system CONOPS. These activities shall consider all segments of the provided mission timeline: mission planning, integration, ERV insertion point generation, return to base and next launch cycle. At a minimum, the trades should be conducted in terms of mission effectiveness and affordability on:

- Mission planning
- ERV integration process
- ERV load up process
- Mission range and loiter time
- Sortie generation rate
- Total system communications requirements
- Operations and support concepts
- Integration with other aircraft operations
- Communications and control elements for the launch including safety aspects

3.3.2 Reusable Launch Vehicle

The contractor shall perform the trades, analyses, and modeling and simulation necessary to define the configuration, attributes, performance, and procurement and O&S cost of the RLV and its subsystems. At a minimum, trades should be conducted in terms of mission effectiveness and affordability on:

- ERV load capability
- Loiter and range capabilities
- Speed, altitude, and cruise efficiency
- Aircraft size and weight
- Aircraft avionics and communications requirements
- Level of control system robustness and redundancy for exo-atmospheric control
- Maintenance and logistics
- Prognostic health monitoring system
- COTS and/or MOTS vs. new aircraft
- Manned vs. Unmanned
- Communications and control elements for the launch including safety aspects

These trades will be conducted iteratively with the CONOPS trades to define an optimized solution.

3.3.3 Expendable Rocket Vehicle

The contractor shall perform the trades, analyses, and modeling and simulation necessary to define the configuration, attributes, performance, and contractor life cycle cost of the ERV and its subsystems. At a minimum, trades should be conducted in terms of mission effectiveness and affordability on:

- Low recurring cost technology
- Storage and handling
- Integration of P/L and to RLV
- P/L delivery performance capability
- RLV separation
- ERV size, weight and performance
- Communications and control elements for the launch including safety aspects
- P/L insertion performance
- Level of control system robustness and system redundancy
- Robust Jettison RLV/ERV interface (ERV jettisoning w/o satellite payload in emergency situations)

3.3.4 Supportability

The contractor shall evaluate logistics issues such as reduced maintenance, reduced personnel, and deployment in all trade studies in the development of the RASCAL design and CONOPS. The objective is to design a launch system whose operations and support costs are comparable to current tactical aircraft squadron or better. At a minimum, trades and analyses should be conducted in terms of mission effectiveness and affordability on:

- Reduced maintenance technologies
- Redundancy and condition based maintenance
- Commercial turnaround practices
- Sortie rates and turnaround time vs. maintenance concept
- Maintenance diagnostic tools
- Logistics support concept vs. employment responsiveness
- Integration with existing aircraft maintenance

3.4 Demonstration and Contractor Life Cycle Cost (CLCC) Analysis

The contractor will develop a comprehensive CLCC model that provides a sound basis for conducting affordability trades on the RASCAL system and associated CONOPS. The contractor will provide a process for analyzing total cost that allows visibility into, and sensitivity determination of, all key parameters. The contractor should also identify all key assumptions and the rationale for their use. All cost analyses shall clearly demonstrate the cost sensitivity to variations in key parameters and assumptions.

The cost analysis will address two issues: The design of the RDS hardware for the best way to accomplish the goals of the RASCAL demonstration and the design of the ROS where a key objective is holding the launch costs to $750,000 or less. The best approach is to achieve a RDS and ROS that are the same or very similar. The government will provide Ground Rules and Assumptions (GR&A) to facilitate these cost analyses and to ensure comparative analysis of competitive ROS systems. The GR&A will include annual launch requirements, numbers of RLVs and ERVs which may be required, (although Contractors may be able to show that fewer vehicles will be required because of the ingenuity and technical features of its' design), military maintenance labor costs, RLV fuel costs, RLV flying hours and values for other variables commonly associated with deploying a military aircraft system.

For the RDS, the cost analyses should address the cost items that must be funded for the demonstration program and describe how values for the items will be developed before the end of the Phase 1 contracts. At a minimum, the RDS cost estimates should encompass the following items:

1. Design and development costs, which might be necessary to complete a satisfactory demonstration of the RDS that evolves from the Phase 1 study. This must cover the RLV, ERV and any peculiar ground support equipment (PGSE or PSE) or facilities, which may be required.
2. Design, fabrication and ground testing of the RLV propulsion system.
3. Fabrication costs for the prototype RLVs, and ERVs, integration of RLV and ERV and GSE necessary to support the demonstration tests. [The number of prototype RLVs and ERVs to be built to satisfy RASCAL demonstration objectives is left to the Offerors to decide based on their analysis of the total RASCAL program objectives]
4. Flight tests of the RLVs and testing of the integrated RASCAL Demonstration System at a government facility.

For ROS, the cost analyses should provide a launch cost model, which will provide estimates of launch costs, based on defined assumptions and describe a methodology for the development of the values for the key variables in the model. The ROS cost estimates should include, at least the following ROS Life Cycle Cost (LCC) items:

1. Design, development and other non-recurring engineering costs[5] which might be necessary after completion of a satisfactory demonstration of the RASCAL Demonstration System (RDS), which evolves from DARPA's three phase concept demonstration. This must cover the RLV, ERV and any peculiar ground support equipment (GSE) or facilities, which may be required.
2. Design, fabrication and ground testing of the engines with the MIPCC system.
3. Investment costs for the RLVs, ERVs and GSE necessary to support an operational launch program.
4. Operating and Support (O&S) costs
5. The cost items cited above should be incorporated into a launch cost model, which will demonstrate how closely the RASCAL design will meet the $750,000 per launch objective.

The GR&A will include estimates, for purposes of the cost analysis, of the required quantities of operational RLVs that will be required, annual procurements of ERVs, numbers of expected launches per year for a multi-year planning horizon, number of bases from which the RASCAL system might operate, and a listing and definitions for cost elements comprising the O&S costs associated with the RLVs and ERVs and aircraft and launch operations.

3.5 Figures of Merit

In order to facilitate all the previously defined trade studies and analyses, and provide a basis of evaluation, the mission effectiveness and affordability of the RDS should be measured against an identical set of defined criteria, or figures of merit which will be determined and provided at the early part of Phase I. In designing the RASCAL, DARPA will also provide a detailed baseline mission scenario in Phase 1.

3.6 Phase 1 TDAP

The contractor shall refine the proposed TDAP to demonstrate and verify the integrated set of critical technologies required to validate the RDS. The TDAP should be refined based on the Phase I activities and proposed TDAP and should include details on planned risk mitigation efforts. Besides Phase II risk reduction efforts, this TDAP shall include (but is not limited to) Phase III subsystem and component verification, vehicle check-out and flight safety

[5] Other non-recurring engineering might include for example, mission control and analysis, logistic support, systems engineering and integration analysis and test, program management, and so on.

assessments, critical technology evaluation and assessments, and flight demonstration of the RDS. The TDAP will address the role of any modeling and simulation in both the planning and conduct of the risk reduction, verification, and testing. Innovative methods for any of the test and evaluation activities should be identified. This overall demonstration effort should explicitly address all demonstration program technical objectives including; mission effectiveness, logistics functionality, command, control, and communications, and affordability.

The proposed test locations, methods and major test parameters are to be identified and shall include any proposed requirements for government test facilities or resources. In subsequent phases, the PM shall endorse those needs and permit the contractor to make arrangement for their use/availability. The cost for the use of those facilities/resources should not be included in the contractor's Phase II proposal but needs to be identified so the Government can compare total demonstration cost during evaluation.

3.7 Meeting Details

All milestone reviews will be conducted at the contractor's location. The purpose of the milestone reviews is to demonstrate accomplishment of milestone exist criteria as a basis for payment. The objective is to convey information and discuss issues, not to generate formal documentation. Instead of written milestone reports, a complete copy of the annotated milestone review briefings shall be provided to the meeting attendees. The contractor will forward an electronic copy of the draft briefing 3 days prior to the meeting and meeting minutes and a electronic briefing to the DARPA PM within a week after the review. The government anticipates sending 10-20 people to each milestone review.

The Phase 1 milestones call for two levels of review. To assist the offeror in determining the anticipated level of effort for each design review, we offer the following definitions, in addition to the milestones as described in Section 3.2.

- Conceptual Design Kick-off Review – A review of the proposed system with the next level of configuration refinement that will result toward meeting the objectives due to the completion of requirements analysis, ConOps development and early engineering trades.

- System Design Review - Results of empirical and parametric methods used to produce a system design where the top level performance and relationships between all major system components (air vehicle, mission control station, and external infrastructure) are defined. Internal arrangement of major subsystems for the RLV, ERV and mission control station (if applicable) has been accomplished. Supportability concepts are defined.

The government anticipates a minimum of one informal face to face technical interchange meeting (TIM) prior to Phase I completion. The objective of a TIM is to allow coordination of government objectives and contractor activities. TIMs are small working level meetings without formal documentation. Attendance at each TIM will be tailored based on the agenda, but the maximum government attendance should be ten people. The TIMs provide an opportunity for the government to view the trades in progress and provide additional insight or information as required. The value of the meetings will be in the breadth of material and level of detail and interaction with the team. Additional TIMs may be conducted via telephone or video teleconference if the appropriate facilities can be made available and the information can be communicated adequately.

4 Proposal Guidance

This section of the solicitation provides the offeror guidance for the development of their Phase I proposals. Key elements of the proposal will be the RASCAL Notional System Concept (NSC), TDAP, Task Description Document (TDD) and RASCAL Demonstration Master Schedule (DMS). The instructions are not intended to be all-inclusive, but should be considered as each offeror develops their proposal.

It is highly probable that DARPA's request for funds will be approved by Congress as envisioned. The Government's obligation under this solicitation and resulting agreement is dependent upon availability of appropriated funds. Offerors are advised that the cost of any response to, or other cost incurred as a result of, this solicitation is at the offerors' risk. Unless funds become available for this requirement, no agreement will be awarded.

4.1 Work Outline

The work outline provides a common numbering system that ties all program elements together. This numbering system integrates the NSC, TDD, and DMS and must be used throughout all program documentation. The NSC, TDD and DMS shall be consistent down through level 3 of the work outline. As the program progresses, this same numbering system shall be used to define the RASCAL Demonstrator System (RDS).

This section describes the work outline as viewed by the Government. The government work outline is provided only for reference and represents the minimal set of program elements. The offeror is free to propose a completely different Work Outline. However, to allow for an equitable comparison of competing concepts the offeror shall ensure their Work Outline addresses all the program elements shown below:

Outline Level

Code	**1**	**2**	**3**	**4**
00000	Responsive Affordable Small Cargo Affordable Launched (RASCAL) System			
10000		Reusable Launch Vehicle (RLV)		
			Airframe	
			Propulsion	
			Vehicle Management System	
			Mission Management System	
			Communications, Command and Control	
			Safety	
			Payload	
			Software	
			Integration and test	
20000		Expendable Rocket Vehicle (ERV)		
			Motors	
			Controls	
			Vehicle Management System	
			Mission Management System	
			Communications, Command and Control	

		Safety
		Payload
		Software
		Integration and test
3000	Mission Control	
		Launch Planning and Control
		Mission Planning & Control
		Communications, Command and Control
		Safety
		Infrastructure
		Software
		Integration and test
30000	Reusable Launch Vehicle Supportability	
		Reliability & Maintainability
		Maintenance Planning
		Deployability
		Support Equipment
		Long Term Storage
		Manpower, Personnel & Training
		Supply Support
		Safety & Health Hazards
40000	Systems Engineering/Program Management	
		Systems Engineering Management
		System Integration
		System Software Development Process
		System Life Cycle Cost
		Manufacturing and Production Planning
		Human Factors
		Specialty Engineering
		Program Management
		Configuration Management
		Financial Management
50000	System Test	
		Risk Reduction
		Systems Integration Laboratory
		Check-out & Flight Safety
		Mission Effectiveness
		Logistics Functionality
		Command & Control
		Communications

4.2 Organization

The offeror shall use the following outline in response to this solicitation.

Executive Summary

<u>Technical Volume</u>

Technical Approach and Substantiation
Notional System Concept (NSC)
Trade Study and Analysis Plan

Management Volume

Management Plan
Key Personnel
Innovative Business Practices
Facilities
Program Team
Past Performance
Proposed Agreement with Attachments
    Task Description Document (TDD)
    Technology Development and Assessment Plan (TDAP)
    Demonstration Master Schedule (DMS)

Cost Volume

Cost Response

4.3 Executive Summary

This document is meant to be an executive level description of key elements and unique features of each offeror's proposed RASCAL Phase I program. The Executive Summary should at least address the offeror's:

1) Program Objectives and Approach
2) Acquisition Approach, including schedule, technical performance risk areas, risk mitigation or reduction activities, and leveraging from Independent Research and Development (IR&D) or other government research activities
3) Top Level Program Schedule
4) Proposed Cost

4.4 Technical Approach and Substantiation

This section of the proposal provides the offeror with the opportunity to explain and substantiate the significant features of their NSC, trade study and analysis plan, TDAP, DMS, and overall technical approach and management plan. The offeror should provide significant details to address all the relevant evaluation criteria outlined in Section 5.

4.4.1 Notional System Concept

The offeror shall describe their top-level vision of a RASCAL system architecture and notional system concept. This is meant to be an initial look that demonstrates the offeror's understanding of the program objectives, performance goals and operational issues. The offeror will not only describe their top-level vision, but will parameterize their concept and major technologies with the model provided in the appendix.

The offeror's NSC will serve as a point of departure for Phase I trade studies. The government does not expect the NSC to be defined to high fidelity but rather will use this information to gauge the offeror's initial thoughts on how to best meet program objectives. To provide a common framework, the offeror's PDSC description shall conform to the single, common program numbering system outlined in their TDD.

4.4.2 Trade Study and Analysis Plan

The trade study and analysis plan shall describe the offeror's approach to progressively refining their NSC into a final demonstration design. Those refinements will be based on a series of concurrent system requirements, design and affordability trades as discussed in section 3.3.

4.5 Management Plan

The offeror shall describe their program management process, based on the concepts of Integrated Product and Process Development (IPPD). A series of tracking tools shall be used and updated monthly. They shall include:

- Demonstration Master Schedule (DMS): The offeror will establish and maintain a master scheduling system that provides continuous status of program accomplishments against time. This tiered system will provide visibility to Level 3 and Level 4 items as appropriate.
- Financial Management System: The offeror will provide a financial management system that allows the government visibility into the program budget and spend plan and is tied to their work outline. The offeror will provide regular cost reports to the Government, at least monthly, in offeror-preferred format.

These tools shall be the same tools used internally to manage the program. No additional unique information for the Government is desired or required.

4.5.1 Key Personnel

Short one page resumes shall be provided for the top four members of the development team. The entire team will be represented by these key personnel. The Government does not desire or require resumes of the key personnel from each partner company, subcontractor or organization within the team. These key personnel should be the leaders of the team and represent the capability and strength of the team. They can be from a single company or distributed across various team members. The Government wishes to understand the strength of the team through its acknowledged leaders and their qualifications.

4.5.2 Innovative Business Practices

The offeror shall describe innovative business practices to be used on this program that provide the potential for cost or schedule benefit as compared to a traditional acquisition program.

4.5.3 Facilities

The offeror will identify facilities needed and available to support all phases of this program.

4.5.4 Program Team

The offeror will describe the proposed program team and demonstrate the team's capability and experience to perform **ALL PHASES** of the RASCAL program.

4.5.5 Past Performance

The offeror shall provide program name, agency, phone # and POC of relevant large scale systems integration experience, large scale software integration experience, flight test experience, and simulation based acquisition experience.

The list of programs the offeror provide should be associated with the comparable development of any following discipline: aircraft, expendable rockets, flight line operations, high powered air breathing turbin engines, GN&C (ACS & RCS), life cycle cost analysis, software, mission planning and control modules, vehicle staging and separation analysis/designs.

4.5.6 Proposed Agreement with Attachments

The offeror's agreement shall follow the outline described in Section 6 (Model Agreement). This section provides specific guidance for preparing Article III and attachments 1 and 2 of that agreement.

4.5.6.1 Article III: Task Description Document (TDD)

The TDD describes the work effort necessary to meet the milestones and Statement of Objectives for Phase I of the RASCAL ATD program. The TDD will include the offeror's plans for trade studies and analyses, RASCAL system concept development, cost analysis tool development and technology assessment. The TDD should define structure tasks consistent with the Work Outline provided in Section 4.1. The offeror may choose to define work at lower levels to better explain their approach. A Notional TDD toward meeting overall program goals and system objectives should be provided for Phase II and III. The TDD will be incorporated into any resultant agreement.

4.5.6.2 Proposed Technology Development and Assessment Plan (TDAP)

The TDAP shall identify the top level metrics, processes, and system level performance and affordability trades the offeror intends to use to identify the critical and enabling Technologies, Processes and System Attributes (TPSAs) that must be validated and/or demonstrated to achieve low risk entry into an acquisition program. A major objective of Phase I is to examine a range of competing technologies that could enable the RASCAL system. The plan shall describe the offeror's process for identifying and evaluating competing technologies available from other government and industry R&D programs. A Notional Phase II and III TDAP will also provide details on meeting overall program goals and system objectives.

4.5.6.3 Demonstration Master Schedule (DMS)

The DMS should outline the detailed tasks and the amount of time expressed in calendar schedules necessary to achieve the milestones and significant functional accomplishments in Phase I. It is a tiered scheduling system corresponding to the RASCAL work outline. The first iteration of the DMS should be to level 3 of the offeror's TDD or lower as determined by the offeror. Definitions and characteristics of the key elements of the DMS are given below.

<u>Detailed Tasks</u>: Detailed work effort to be completed in support of a specific significant milestone or functional accomplishment.

Calendar Schedule: Detailed schedule (dates) of the period of performance for each work effort.

An initial DMS shall be delivered with the Phase I proposal.

4.6 Cost Response

The cost response should be in the offeror's format. Certified cost or pricing data is not required. However, in order for the Government to determine the reasonableness, realism and completeness of your cost proposal, the following data must be provided for each team member and in a cumulative summary:

Labor: Total labor includes direct labor and all indirect expenses associated with labor, to be used in the RASCAL ATD Phase I period of performance. Provide a breakdown of labor and rates for each category of personnel to be used on this project.

Direct Materials: Total direct material that will be acquired and/or consumed in the RASCAL ATD Phase I period of performance. Limit this information to only major items of material and how the estimated expense was derived. For this agreement a major item exceeds $250,000.

Subcontracts: Describe major efforts to be subcontracted, the source, estimated cost and the basis for this estimate. For this agreement a major effort exceeds $250,000.

Travel: Total proposed travel expenditures relating to the RASCAL ATD Phase I period of performance. Limit this information to the number of trips, and purpose of each cost.

Other Costs: Any direct costs not included above. List the item, the estimated cost, and basis for the estimate.

Remember the cost proposal should tell the story of how and why you are planning to complete your proposed Phase I TDD. Activities such as demonstrations required to reduce the various technical risks should be identified in the TDD and reflected in the cost proposal.

The offeror should provide a total estimated price for any IR&D activities associated with the program. The offeror should state whether each program is a dedicated IR&D or if it is being pursued to benefit other programs as well.

4.7 Administrative Instructions

4.7.1 Page and Print Information

The Solicitation Response should be submitted in standard three-ring, loose leaf binders with individual pages unbound and printed single sided to facilitate page changes. The response shall not exceed 50 pages total, including attachments and the classified annex. Indexes, cross reference tables, and tabs will not be included in the page count. The proposed agreement with attachments will not be included in the page count. Page count will be based on the offeror's hardcopy submission. Six copies shall be provided. The suggested page limits for each section are as follows:

1) Executive Summary 2 pages
2) Technical Volume 12 pages
    a. Technical Approach and Substantiation
    b. Notional System Concept
    c. Trade Study and Analysis Plan
3) Management Volume 9 pages

a. Management Plan
b. Innovative Business Practices
c. Facilities
d. Program Team
e. Past Performance
f. Proposed Agreement with Attachments Not included in page count
    i. Task Description Document (TDD)
    ii. Technology Development and Assessment Plan (TDAP)
    iii. Demonstration Master Schedule (DMS)

4) Cost Volume 25 pages
5) Classified Annex 2 pages

Authorized representatives of the offeror must sign proposal volumes.

Each page should be printed on an 8-1/2" x 11" sheet using Times New Roman 12-point font. Graphics should not include text in smaller than 8-point font. Fold out pages will be counted as multiple pages. Pages should be marked **SOURCE SELECTION SENSITIVE.**

Teams are required to submit their proposal in Microsoft Office 2000 compatible electronic format on CD-ROM. Documents containing imported graphics (drawings, charts, photos, etc.) should be accompanied by the originally imported graphics files. All responses must be received on or before Friday, February 4th, 2002 at 5:00 PM Eastern Standard Time. Late responses will not be accepted.

4.7.1.1 Unclassified Information

The unclassified portion of the offeror's proposal shall be mailed or hand carried to:

Defense Advanced Research Projects Agency (DARPA)
RASCAL Program
3701 North Fairfax Drive
Arlington, VA 22203-1714
Attn: Contracts Management Office
Solicitation Number: Program Solicitation 02-02

Responses and response modifications (which will only be accepted prior to the deadline for receipt of response) shall be submitted in sealed envelopes or packages to the address shown above and marked with the following information on the outer wrapping:

Offeror's name and return address
The response receipt address above
Solicitation Number: Program Solicitation 02-02
Hour and due date:

4.7.2 Changes to the Model Agreement

The offeror can propose any changes, additions, or deletions to the Model Agreement that should be considered during Agreement negotiations. Fully explain the rationale for the changes made in an addendum to the Agreement. Rationale located in other areas of the solicitation response may be cross-referenced. It is the governments' intent to begin negotiating the Phase I agreements as soon as the proposals are received.

4.7.3 Regulations Governing Objections to Solicitation and Award

Any objections to the terms of this solicitation or to the conduct of receipt, evaluation or award of agreements must be presented in writing within ten calendar days of (1) the release of this solicitation, or (2) the date the objector knows or should have known the basis for its objection. Objections should be provided in letter format, clearly stating that it is an objection to this solicitation or to the conduct of evaluation or award of an agreement, and providing a clearly detailed factual statement of the basis for objection. Failure to comply with these directions is a basis for summary dismissal of the objection. Mail objections to the address listed in the proposal delivery information.

5 Evaluation Criteria

5.1 Introduction

DARPA will award multiple Agreements for Phase I of the RASCAL Demonstration program. An updated solicitation will be issued for Phase II and III and the selected contractors' agreements will be modified to extend them appropriately. The Phase I selection will be accomplished based on a subjective evaluation of proposals as described in this section of the solicitation. There are three specific areas of evaluation that will be used, listed in descending order of importance: Product Capability and Technical Approach, Management and Cost. Each offeror's proposal will receive an integrated evaluation by a single multi-functional team. The government reserves the right to award without discussions.

5.2 Basis for Phase I Award

Successful Phase I proposals will incorporate a balanced consideration of all three evaluation areas and provide best value to the government.

5.2.1 Product Capability and Technical Approach

The offeror's Notional System Concept (NSC), Trade Study and Analysis Plan, and Technology Development and Assessment Plan will be evaluated to determine how well they will satisfy the all phases of RASCAL Program Objectives, as well as the detailed Phase I Statement of Objectives. The following sub-factors and criteria will be used to perform the technical evaluation of the offeror's proposed technical approach and substantiation.

5.2.1.1 Notional System Concept

1) Feasibility
2) Responsiveness to program goals and mission
3) Acceptable point of departure for accomplishing trade studies
4) Ability to accommodate range of technologies to be considered

5.2.1.2 Trade Study and Analysis Plan

1. Comprehensive plan that fully explores trade space
2. Includes robust assessment of range of available technologies across government and industry
3. Modeling tools

5.2.1.3 Technology Development and Assessment Plan

1. Robust process for identifying critical technologies, processes and system attributes
2. Detailed plan for evaluating and down selecting among competing component technologies

5.3 Management

The offeror's management and system engineering process will be evaluated to ensure that overall sound methodologies that represent good management practices are used to complete all proposed activities described in the offeror's TDD, TDAP and DMS. Streamlined and innovative business, teaming and technical management practices are desired. The evaluation will examine the offeror's proposal in the areas listed below:

5.3.1 Management Plan - All aspects of the proposal will be analyzed to determine if the offeror has the planning, management, system engineering and software development processes, lifecycle cost approach, security and qualified program team to successfully accomplish the tasks defined in their TDD, TDAP and DMS.

5.3.2 Innovative Business Practices -- The offeror will be evaluated based on their proposed application of innovative business practices to reduce the cost and schedule required to achieve the required level of performance as compared to a typical acquisition program

5.3.3 Facilities – The offeror will be evaluated on their access to facilities required for the performance of Phase I tasks. The offeror will also be evaluated on their plans and arrangements to provide the required facilities for potential Phase II and Phase III tasks.

5.3.4 Program Team

The offeror's team composition will be evaluated based on:

a. Key personnel, including the PM, Chief Engineer, and Analysis Lead.
b. The team's ability to execute the program from conceptual design through fabrication and flight test, including the demonstrated ability to produce systems of this complexity.
c. The breadth and depth of the proposed team in advanced aircraft and spacecraft development programs
d. The proposed management construct.

5.3.5 Past Performance – Relevant large scale systems integration experience, large scale software integration experience, flight test experience, and simulation based acquisition experience of the team and its members should be given.

5.3.6 Proposed Agreement Terms and Conditions – All aspects of the proposal will be analyzed to determine the reasonableness of the terms and conditions.

5.3.7 Demonstrated Master Schedule (DMS) – The detail, reasonableness, and completeness of the DMS will be analyzed.

5.4 Cost

This evaluation factor will focus on the cost realism, reasonableness, and completeness as well as the cost benefit of the proposed program to achieving the complete set of RASCAL demonstration goals and objectives. The extent of benefits, if any, included in the offeror's Phase I proposal due to the offeror's IRAD, corporate investments, or other sources must be clearly stated

5.5 Basis for Phase II Award

The government plans to develop a new solicitation for Phase II. The products of Phase I, as well as the offeror's performance, will form the basis of the Phase II evaluation criteria. These criteria will be defined in a revised Phase II solicitation.

6 Model Agreement

6.1 Model Agreement

AGREEMENT

BETWEEN

(INSERT NAME AND ADDRESS)

AND

THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
3701 NORTH FAIRFAX DRIVE
ARLINGTON, VA 22203-1714

CONCERNING

RESPONSIVE ACCESS, SMALL CARGO, & AFFORDABLE LAUNCH (RASCAL)
DEMONSTRATION PROGRAM

PHASE I

Agreement No.: MDA972-02-9-00XX
DARPA Order No.:
Total Estimated Government Funding of the Phase I Agreement: $
Funds Obligated: $
Authority: 10 U.S.C. 2371 and Section 845 of the 1994 National Defense Authorization Act as amended

Line of Appropriation: AA

This Agreement is entered into between the United States of America, hereinafter called the Government, represented by The Defense Advanced Research Projects Agency (DARPA), and the (INSERT NAME) pursuant to and under U.S. Federal law.

FOR (INSERT CONTRACTOR NAME)	FOR THE UNITED STATES OF AMERICA THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
(Signature)	(Signature)
(Name, Title) (Date)	(Name, Title) (Date)

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ATTACHMENTS

ATTACHMENT 1	Task Description Document (TDD)
ATTACHMENT 2	Technology Development and Assessment Plan (TDAP)
ATTACHMENT 3	Demonstration Master Schedule (DMS)

ARTICLE I: SCOPE

This article should state your vision for the Phase I of the RASCAL Program and describe how your proposed program satisfies the Statement of Objectives. This article should summarize the scope of the work you are committing to (as described in detail in Attachment 1, Task Description Document) and the business arrangement entered into by this Agreement.

In addition, this article should discuss the way you will interact with the DARPA program team. Suggested wording (paragraphs used in other DARPA Agreements) for your consideration follows:

“DARPA will have continuous involvement with the Contractor. DARPA will obtain access to program results and certain rights to data and patents pursuant to Articles VII and VIII. “

“This Agreement is an Other Transaction pursuant to 10 U.S.C. 2371 and Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. The Federal Acquisition Regulation (FAR) and Department of Defense FAR Supplement (DFARS) apply only as specifically referenced herein. This Agreement is not intended to be, nor shall it be construed as, by implication or otherwise, a partnership, a corporation, or other business organization.”

“This Agreement is not a traditional FAR/DFARS contract. This Agreement can best be described as Government’s Fixed Dollar Obligation tied to Payable Milestone as evidenced by completion of the milestone accomplishment criteria. The payable milestones with substantial task or performance accomplishment criteria, not strict exit criteria are subject to approval by the Government Program Manager. If needed, prospective adjustments to the payable milestones can be made in accordance with Article IV (C) Modifications, but the total Government Funding for Phases 1 cannot exceed $ for the scope identified herein. The Government has no obligation to pay for uncompleted Payable Milestones.”

Terms such as "Contractor", "parties", "program"; etc. should also be defined in this article. Should "Contractor" be a team, alliance, partnership or other arrangement, this article must reflect these provisions and specifically document the relationship between DARPA and the "unique" Contractor arrangement.

It is recommended that this Article be broken into three sections for Vision, Scope and Agreement.

ARTICLE II: TERM

A. The Term of this Agreement

This Agreement commences upon the date of the last signature hereon and continues for the duration of Phase I of the RASCAL Program. This Agreement will be updated at various points to provide for downselection and phase transition. This Agreement ends at any downselect decision point at which the Contractor is unsuccessful.

B. Termination Provisions

Subject to a reasonable determination that the program will not produce beneficial results commensurate with the expenditure of resources, either Party may terminate this Agreement by written notice to the other Party, provided that such written notice is preceded by consultation between the Parties. In the event of a termination of the Agreement, it is agreed that disposition of subject inventions and data first developed under this Agreement shall be in accordance with the provisions set forth-in Articles VII and VIII. The Government, acting through the Agreements Officer, and the Contractor will negotiate in good faith a reasonable and timely adjustment of all outstanding issues between the Parties as a result of termination. Failure of the Parties to agree to a reasonable adjustment will be resolved pursuant to Article VI, Disputes. The Government has no obligation to pay for any milestones to the Contractor, beyond the last completed and paid milestone, if the Contractor decides to terminate.

C. Extending the Term

The Parties may extend by mutual written agreement the term of this Agreement and research opportunities reasonably warrant. The Agreements Officer and the Contractor Administrator shall formalize any extension through modification of the Agreement.

ARTICLE III: ATTACHMENTS

1. **Task Description Document** - The offeror will submit a TDD and Demonstration Master Schedule (DMS), in accordance with the guidance provided in the section of this solicitation. The TDD will become Attachment 1 to this agreement.
2. **Technology Development and Assessment Plan -** The offeror will submit a TDAP in accordance with the guidance provided in the section of this solicitation. The TDAP will become Attachment 2 to this agreement.
3. **Demonstration Master Schedule** - The offeror will submit a DMS in accordance with the guidance provided in the section of this solicitation. The DMS will become Attachment 3 to this agreement.

ARTICLE IV: PAYABLE EVENT SCHEDULE

A. Payment Schedule

The Contractor shall be paid for performing the work required by the TDD (Article III) in accordance with the amounts and schedule set forth below. Milestone content, locations, and exit criteria are described in section 3.2 of the solicitation/master document. Both the Schedule of Payments and the Funding Schedule set forth below may be revised or modified in accordance with paragraph C.

B. Schedule of Payments and Payable Milestones

Phase I:

MS	Payment	Schedule	Event
1	40%	2 months after award	Conceptual Design Kick Off
2	50%	8 months after award	System Design Review
3	10%	9 months after award/End of Phase I	Final Report/updates to System Design Review

The Team shall propose milestone accomplishment criteria and deliverables to be incorporated into this agreement. Reference Government-provided criteria shown below as a starting point for your proposal.

- Milestone 1 – Concept Design Kick Off - within 2 Months After Award
    - ♦ Information presented:
        - o A preferred concept design
        - o Results of system requirements analyses, initial design trades, and refinement of CONOPS
        - o Methodology of RDS and ROS life cycle cost analysis

    - ♦ Minimum Exit Criteria:
        - o Next level of system design detail and CONOPS trade space described in Section 3.3 explored at the conceptual level

- Identification of Key trades / analysis
- Key RDS and ROS cost model components and assumptions defined[6]

- Milestone 2 – System Design Review - after 7 1/2 Months after award
  - Information presented:
    - Final results of system requirements definition
    - Results of design trades and CONOPS studies
    - Preliminary listing of critical and enabling technologies
    - Demonstrator System Design Review (SDR)
    - Results of Draft ROS launch cost model development and cost element assessments
    - TDAP
    - Review of Phase I results

  - Minimum Exit Criteria: Information presented demonstrates a;
    - CONOPS trades described in Section 3.3 fully explored
    - Demonstrator System Level design:
      - which addresses the critical and enabling technologies and
      - with all functional interface requirements established,
      - sufficient level of effectiveness and affordability as measured against the figures of merit.
    - Sufficient level of validation in the LCC model[7]
    - Updated TDAP which clearly articulates key features of all the Phase II risk reduction efforts, critical technology evaluations and assessments, and Phase III subsystem and component verification, vehicle check-out and flight safety, and flight demonstrations of the RDS,
    - Satisfactory completion and information presented clearly articulates all the results of TDD activities
    - RDS SDR demonstrated sufficient merit to warrant proceeding to the next phase

- Milestone 3 – Report submittal
  - Information submitted:
    - Final report
    - Any updates of the SDR presentation with annotated notes on CD Rom
    -

C. Modifications

1. At any time during the term of the Agreement, progress or results may indicate that a change in the TDD and/or the Payable Milestones, would be beneficial to program objectives. Recommendations for modifications, including justifications to support any changes to the TDD and/or the Payable Milestones, will be documented in a letter and submitted by the Contractor to the DARPA Program Manager with a copy to the DARPA Agreements Administrator. This letter will detail the technical, chronological, and financial impact of the proposed modification to the research program. Any subsequent modification is subject to mutual agreement. The Government is not obligated to pay for additional or revised Payable Milestones until the Payable Milestones Schedule is formally revised by the DARPA Agreements Administrator and made part of this Agreement.

2. The DARPA Program Manager shall be responsible for the review and verification of any recommendations to revise or otherwise modify the Agreement TDD, Schedule of Payments and Payable Milestones, or other proposed changes to the terms and conditions of this Agreement.

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[6] Evaluate launch costs and the methodology for development of the cost estimates for each cost element required to exercise the model

[7] Address cost estimates created to exercise the model, results obtained and the sensitivity of total launch costs to values of the key variables. Suitable documentation will be required to lend credibility to the cost estimates. [In subsequent phases of the RDS, the contractor will be expected to refine the launch cost analysis.]

3. For minor or administrative Agreement modifications (e.g., changes in the paying office or appropriation data, changes to Government or Contractor personnel identified in the Agreement, etc.) no signature is required by the Contractor.

4. The Government will be responsible for effecting all modifications to this agreement.

ARTICLE V: AGREEMENT ADMINISTRATION

Administrative and contractual matters under this Agreement shall be referred to the following representatives of the parties:

DARPA, Mark Bennington, Agreements Officer, (703) 696-2411

CONTRACTOR:(INSERT NAME)(Contractor Administrator)(INSERT TELEPHONE NUMBER)

Technical matters under this Agreement shall be referred to the following representatives:

DARPA: Preston Carter, Program Manager, (703) 696-7500

____________________, Agreements Officer Representative, _________________

CONTRACTOR: (INSERT NAME) (INSERT TITLE) (INSERT TELEPHONE NUMBER)

Each party may change its representatives named in this Article by written notification to the other party. The Government will effect the change as stated in item C.4 of article IV above.

ARTICLE VI: OBLIGATION AND PAYMENT

(NOTE): The parties will negotiate payment methods for later phases prior to the start of performance for each phase. If the payment method agreed upon is a type of cost reimbursement, then we anticipate compliance with current Cost Accounting Standards (CAS) will be required. If the offeror's accounting system does not comply with CAS, the government will consider other payment approaches.)

A. Obligation

The Government's liability to make payments to the Contractor is limited to only those funds obligated under this Agreement or by amendment to the Agreement. DARPA may obligate funds to the Agreement incrementally.

B. Payments

1. Prior to the submission of invoices to DARPA by the Contractor Administrator, the Contractor shall have and maintain an accounting system which complies with Generally Accepted Accounting Principles (unless CAS applies), and with the requirements of this Agreement, and shall ensure that appropriate arrangements have been made for receiving, distributing and accounting for Federal funds.

2. The contractor shall document the accomplishments of each Payable Milestone by submitting or otherwise providing the Payable Milestones Report as required. The contractor shall submit an original and one (1) copy of all invoices to the Agreements Officer for payment approval. After written verification of the accomplishment of the Payable Milestone by the DARPA Program Manager, and approval by the Agreements Officer, the invoices will be forwarded to the payment office within fifteen (15) calendar days of receipt of the invoices at DARPA. Payment approval for the final Payable Milestone will be made after reconciliation. Payments will be made by Defense Accounting Office, DFAS, Attention: Vendor Pay, 8899 East 56th Street, Indianapolis, IN 46249-1325 within fifteen

(15) calendar days of DARPA's transmittal. Subject to change only through written Agreement modification, payment shall be made to the address of the contract's Administrator set forth below.

3. Address of Payee: (INSERT NAME AND ADDRESS OF PAYEE)

4. Limitation of Funds: In no case shall the Government's financial liability exceed the amount obligated under this Agreement.

5. Financial Records and Reports: The Contractor's relevant financial records are subject to examination or audit on behalf of DARPA by the Government for a period not to exceed three (3) years after expiration of the term of this Agreement. The Contractors shall provide the Agreements Administrator or designatee direct access to sufficient records and information of the Contractor to ensure full accountability for all funding under this Agreement. Such audit, examination, or access shall be performed during business hours on business days upon prior written notice and shall be subject to the security requirements of the audited party.

6. Comptroller General Access to Records: To the extent that the total government payments under this Agreement exceed $5,000,000, the Comptroller General, at its discretion, shall have access to and the right to examine records of any party to the agreement or any entity that participates in the performance of this agreement that directly pertain to and involve transactions relating to, the agreement for a period of three (3) years after final payment is made. This requirement shall not apply with respect to any party to this agreement or any entity that participates in the performance of the agreement, or any subordinate element of such party or entity, that has not entered into any other agreement (contract, grant, cooperative agreement, or "other transaction") that provides for audit access by a government entity in the year prior to the date of this agreement. This paragraph only applies to any record that is created or maintained in the ordinary course of business or pursuant to a provision of law. The terms of this paragraph shall be included in all sub-agreements to the Agreement.

ARTICLE VII: DISPUTES

A. General

Parties shall communicate with one another in good faith and in a timely and cooperative manner when raising issues under this Article.

B. Dispute Resolution Procedures

1. Any disagreement, claim or dispute between the Government and the Contractor concerning questions of fact or law arising from or in connection with this Agreement, and, whether or not involving an alleged breach of this Agreement, may only be raised under this Article.

2. Whenever disputes, disagreements, or misunderstandings arise, the Parties shall attempt to resolve the issue(s) involved by discussion and mutual agreement as soon as practicable. In no event shall a dispute, disagreement or misunderstanding which arose more than three (3) months prior to the notification made under subparagraph B.3 of this article constitute the basis for relief under this article unless the Director of DARPA in the interests of justice waives this requirement.

3. Failing resolution by mutual Agreement, the aggrieved Party shall document the dispute, disagreement, or misunderstanding by notifying the other Party (through the DARPA Agreements Administrator or Contractor Administrator, as the case may be) in writing of the relevant facts, identify unresolved issues, and specify the clarification or remedy sought. Within five (5) working days after providing notice to the other Party, the aggrieved Party may, in writing, request a joint decision by the DARPA Director, Contract Management Office and Representative of the Contractor ("Contractor Representative"). The other Party shall submit a written position on the matter(s) in dispute within thirty (30) calendar days after being notified that a decision has been requested. The Deputy Director for Management and the Contractor Representative shall conduct a review of the matter(s) in

dispute and render a decision in writing within thirty (30) calendar days of receipt of such written position. Any such joint decision is final and binding unless a Party shall, within thirty (30) calendar days, request further review as provided in this Article.

4. Upon written request to the Director of DARPA, made within thirty (30) calendar days or upon unavailability of a joint decision under subparagraph B.3 above, the dispute shall be further reviewed. The Director of DARPA may elect to conduct this review personally or through a designatee or jointly with a representative of the other Party who is a senior official of the Party. Following the review, the Director of DARPA or designatee will resolve the issue(s) and notify the Parties in writing. Such resolution is not subject to further administrative review and, to the extent permitted by law, shall be final and binding.

ARTICLE VIII: PATENT RIGHTS

A. Definitions

1. "Invention" means any invention or discovery that is or may be patentable or otherwise protectable under Title 35 of the United States Code.

2. "Made" when used in relation to any invention means the conception or first actual reduction to practice of such invention.

3. "Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method, or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is capable of being utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

4. "Subject invention" means any Contractor invention conceived or first actually reduced to practice in the performance of work under this Agreement.

B. Allocation of Principal Rights

Unless the Contractor shall have notified DARPA (in accordance with subparagraph C.2 below) that the Contractor does not intend to retain title, the Contractor shall retain the entire right, title, and interest throughout the world to each subject invention consistent with the provisions of the Articles of Collaboration, this Article, and 35 U.S.C. § 202. With respect to any subject invention in which the Contractor retains title, DARPA shall have a non-exclusive, nontransferable, irrevocable, paid-up license to practice or have practiced on behalf of the United States the subject invention throughout the world. Notwithstanding the above, the Contractor may elect as defined in its Articles of Collaboration to provide full or partial rights that it has retained to Contractor or other parties.

C. Invention Disclosure, Election of Title, and Filing of Patent Application

1. The Contractor shall disclose each subject invention to DARPA within four (4) months after the inventor discloses it in writing to his company personnel responsible for patent matters. The disclosure to DARPA shall be in the form of a written report and shall identify the Agreement under which the invention was made and the identity of the inventor(s). It shall be sufficiently complete in technical detail to convey a clear understanding to the extent known at the time of the disclosure, of the nature, purpose, operation, and the physical, chemical, biological, or electrical characteristics of the invention. The disclosure shall also identify any publication, sale, or public use of the invention and whether a manuscript describing the invention has been submitted for publication and, if so, whether it has been accepted for publication at the time of disclosure. The Contractor shall also submit to DARPA an annual listing of subject inventions.

2. If the Contractor determines that it does not intend to retain title to any such invention, the Contractor shall notify DARPA, in writing, within eight (8) months of disclosure to DARPA. However, in any case where publication, sale,

or public use has initiated the one (1)-year statutory period wherein valid patent protection can still be obtained in the United States, the period for such notice may be shortened by DARPA to a date that is no more than sixty (60) calendar days prior to the end of the statutory period.

3. The Contractor shall file its initial patent application on a subject invention to which it elects to retain title within one (1) year after election of title or, if earlier, prior to the end of the statutory period wherein valid patent protection can be obtained in the United States after a publication, or sale, or public use. The Contractor may elect to file patent applications in additional countries (including the European Patent Office and the Patent Cooperation Treaty) within either ten (10) months of the corresponding initial patent application or six (6) months from the date permission is granted by the Commissioner of Patents and Trademarks to file foreign patent applications, where such filing has been prohibited by a Secrecy Order.

4. Requests for extension of the time for disclosure election, and filing under Article VII, paragraph C, may, at the discretion of DARPA, and after considering the position of the Contractor, be granted.

D. Conditions When the Government May Obtain Title

Upon DARPA's written request, the Contractor shall convey title to any subject invention to DARPA under any of the following conditions:

1. If the Contractor fails to disclose or elects not to retain title to the subject invention within the times specified in paragraph C of this Article; provided, that DARPA may only request title within sixty (60) calendar days after learning of the failure of the Contractor to disclose or elect within the specified times.

2. In those countries in which the Contractor fails to file patent applications within the times specified in paragraph C of this Article; provided, that if the Contractor has filed a patent application in a country after the times specified in paragraph C of this Article, but prior to its receipt of the written request by DARPA, the Contractor shall continue to retain title in that country; or

3. In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceedings on, a patent on a subject invention.

E. Minimum Rights to the Contractor and Protection of the Contractor's Right to File

1. The Contractor shall retain a non-exclusive, royalty-free license throughout the world in each subject invention to which the Government obtains title, except if the Contractor fails to disclose the invention within the times specified in paragraph C of this Article. The Contractor license extends to the domestic (including Canada) subsidiaries and affiliates, if any, of the Contractor within the corporate structure of which the Contractor is a party and includes the right to grant licenses of the same scope to the extent that the Contractor was legally obligated to do so at the time the Agreement was awarded. The license is transferable only with the approval of DARPA, except when transferred to the successor of that part of the business to which the invention pertains. DARPA approval for license transfer shall not be unreasonably withheld.

2. The Contractor domestic license may be revoked or modified by DARPA to the extent necessary to achieve expeditious practical application of the subject invention pursuant to an application for an exclusive license submitted consistent with appropriate provisions at 37 CFR Part 404. This license shall not be revoked in that field of use or the geographical areas in which the Contractor has achieved practical application and continues to make the benefits of the invention reasonably accessible to the public. The license in any foreign country may be revoked or modified at the discretion of DARPA to the extent the Contractor, its licensees, or the subsidiaries or affiliates have failed to achieve practical application in that foreign country.

3. Before revocation or modification of the license, DARPA shall furnish the Contractor a written notice of its intention to revoke or modify the license, and the Contractor shall be allowed thirty (30) calendar days (or such other

time as may be authorized for good cause shown) after the notice to show cause why the license should not be revoked or modified.

F. Action to Protect the Government's Interest

1. The Contractor agrees to execute or to have executed and promptly deliver to DARPA all instruments necessary to (i) establish or confirm the rights the Government has throughout the world in those subject inventions to which the Contractor elects to retain title, and (ii) convey title to DARPA when requested under paragraph D of this Article and to enable the Government to obtain patent protection throughout the world in that subject invention.

2. The Contractor agrees to require, by written agreement, that employees of the Members of the Contractor, other than clerical and non-technical employees, agree to disclose promptly in writing, to personnel identified as responsible for the administration of patent matters and in a format acceptable to the Contractor, each subject invention made under this Agreement in order that the Contractor can comply with the disclosure provisions of paragraph C of this Article. The Contractor shall instruct employees, through employee agreements or other suitable educational programs, on the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

3. The Contractor shall notify DARPA of any decisions not to continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceedings on a patent, in any country, not less than thirty (30) calendar days before the expiration of the response period required by the relevant patent office.

4. The Contractor shall include, within the specification of any United States patent application and any patent issuing thereon covering a subject invention, the following statement: "This invention was made with Government support under Agreement No. MDA972-9*-3-00** awarded by DARPA. The Government has certain rights in the invention."

G. Lower Tier Agreements

The Contractor shall include this Article, suitably modified, to identify the Parties, in all subcontracts or lower tier agreements, regardless of tier, for experimental, development, or research work.

H. Reporting on Utilization of Subject Inventions

The Contractor agrees to submit, during the term of the Agreement, an annual report on the utilization of a subject invention or on efforts at obtaining such utilization that are being made by the Contractor or its licensees or assignees. Such reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the subcontractor(s), and such other data and information as the agency may reasonably specify. The Contractor also agrees to provide additional reports as may be requested by DARPA in connection with any march-in proceedings undertaken by DARPA in accordance with paragraph J of this Article. Consistent with 35 U.S.C. § 202(c)(5), DARPA agrees it shall not disclose such information to persons outside the Government without permission of the Contractor.

I. Preference for American Industry

Notwithstanding any other provision of this clause, the Contractor agrees that it shall not grant to any person the exclusive right to use or sell any subject invention in the United States or Canada unless such person agrees that any product embodying the subject invention or produced through the use of the subject invention shall be manufactured substantially in the United States or Canada. However, in individual cases, the requirements for such an agreement may be waived by DARPA upon a showing by the Contractor that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that, under the circumstances, domestic manufacture is not commercially feasible.

J. March-in Rights

The Contractor agrees that, with respect to any subject invention in which it has retained title, DARPA has the right to require the Contractor, an assignee, or exclusive licensee of a subject invention to grant a non-exclusive license to a responsible applicant or applicants, upon terms that are reasonable under the circumstances, and if the Contractor, assignee, or exclusive licensee refuses such a request, DARPA has the right to grant such a license itself if DARPA determines that:

1. Such action is necessary because the Contractor or assignee has not taken effective steps, consistent with the intent of this Agreement, to achieve practical application of the subject invention;

2. Such action is necessary to alleviate health or safety needs that are not reasonably satisfied by the Contractor, assignee, or their licensees;

3. Such action is necessary to meet requirements for public use and such requirements are not reasonably satisfied by the Contractor, assignee, or licensees; or

4. Such action is necessary because the agreement required by paragraph (I) of this Article has not been obtained or waived or because a licensee of the exclusive right to use or sell any subject invention in the United States is in breach of such Agreement.

ARTICLE IX: DATA RIGHTS

Limited Rights in all data delivered under Phase I of this agreement is desired if the Team is proposing a cost-share arrangement for this phase. In that case, the Government will use this information for RASCAL program uses only. Additional rights shall be required in following phases that are retroactive back to Phase I for successful Teams. The following standard Government Data Rights Article is offered as a point of departure in this case.

A. Definitions

1. "Government Purpose Rights", as used in this article, means rights to use, duplicate, or disclose Data, in whole or in part and in any manner, for Government purposes only, and to have or permit others to do so for Government purposes only.

2. "Unlimited Rights", as used in this article, means rights to use, duplicate, release, or disclose, Data in whole or in part, in any manner and for any purposes whatsoever, and to have or permit others to do so.

3. "Data", as used in this article, means recorded information, regardless of form or method of recording, which includes but is not limited to, technical data, software, trade secrets, and mask works. The term does not include financial, administrative, cost, pricing or management information and does not include subject inventions included under Article VIII.

4. "Limited rights" as used in this article means the rights to use, modify, reproduce, release, perform, display, or disclose technical data, in whole or in part, within the Government. The Government may not, without the written permission of the party asserting limited rights, release or disclose the data outside the Government, use the technical data for manufacture, or authorize the technical data to be used by another party.

B. Allocation of Principal Rights

1. This Agreement is performed with mixed Government and Team funding. The Parties agree that in consideration for Government funding, the Team intends to reduce to practical application items, components and processes developed under this Agreement.

2. The Team agrees to retain and maintain in good condition until (INSERT NUMBER OF YEAR) (___) years after completion or termination of this Agreement, all Data necessary to achieve practical application. In the event of exercise of the Government's March-in Rights as set forth under Article VIII or subparagraph B.3 of this article, the Team, acting through its Team Lead, agrees, upon written request from the Government, to deliver at no additional cost to the Government, all Data necessary to achieve practical application within sixty (60) calendar days from the date of the written request. The Government shall retain Unlimited Rights, as defined in paragraph A above, to this delivered Data.

3. The Team agrees that, with respect to data necessary to achieve practical application, DARPA has the right to require the Team to deliver all such data to DARPA in accordance with its reasonable directions if DARPA determines that:

(a) Such action is necessary because the Team or assignee has not taken effective steps, consistent with the intent of this Agreement, to achieve practical application of the technology developed during the performance of this Agreement;

(b) Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the Team, assignee, or their licensees; or

(c) Such action is necessary to meet requirements for public use and such requirements are not reasonably satisfied by the Team, assignee, or licensees.

C. Marking of Data

Pursuant to paragraph B above, any data delivered under this Agreement shall be marked with the following legend:

> “Use, duplication, or disclosure is subject to the restrictions as stated in Agreement MDA972-02-9-XXXX between the Government and the Team.”

D. Lower Tier Agreements

The Consortium shall include this Article, suitably modified to identify the Parties, in all subcontracts or lower tier Agreements, regardless of tier.

ARTICLE X: FOREIGN ACCESS TO TECHNOLOGY

(NOTE: It is DARPA's intention to restrict this technology from flowing overseas without approval to ensure the economic and security issues have been resolved prior to any release. If the offerors desire proposed changes to this article they should explain the rationale completely.)

This Article shall remain in effect during the term of the Agreement and for five years thereafter.

A. Definition

"Foreign Firm or Institution" means a firm or institution organized or existing under the laws of a country other than the United States, its territories, or possessions. The term includes, for purposes of this Agreement, any agency or instrumentality of a foreign government; and firms, institutions or business organizations that are owned or substantially controlled by foreign governments, firms, institutions, or individuals.

"Know-How" means all information including, but not limited to discoveries, formulas, materials, inventions, processes, ideas, approaches, concepts, techniques, methods, software, programs, documentation, procedures, firmware, hardware, technical data, specifications, devices, apparatus and machines.

"Technology" means discoveries, innovations, Know-How and inventions, whether patentable or not, including computer software, recognized under U.S. law as intellectual creations to which rights of ownership accrue including, but not limited to, patents, trade secrets, maskworks, and copyrights developed under this Agreement.

B. General

The Parties agree that research findings and technology developments in (INSERT TYPE OF TECHNOLOGY) technology may constitute a significant enhancement to the national defense, and to the economic vitality of the United States. Accordingly, access to important technology developments under this Agreement by Foreign Firms or Institutions must be carefully controlled. The controls contemplated in this Article are in addition to, and are not intended to change or supersede, the provisions of the International Traffic in Arms Regulation (22 CFR pt. 121 et seq.), the DoD Industrial Security Regulation (DoD 5220.22-R) and the Department of Commerce Export Regulation (15 CFR pt. 770 et seq.)

C. Restrictions on Sale or Transfer of Technology to Foreign Firms or Institutions

1. In order to promote the national security interests of the United States and to effectuate the policies that underlie the regulations cited above, the procedures stated in subparagraphs C.2, C.3, and C.4 below shall apply to any transfer of Technology. For purposes of this paragraph, a transfer includes a sale of the company, and sales or licensing of Technology. Transfers do not include:

(a) sales of products or components, or
(b) licenses of software or documentation related to sales of products or components, or
(c) transfer to foreign subsidiaries of the Contractor for purposes related to this Agreement, or
(d) transfer which provides access to Technology to a Foreign Firm or Institution which is an approved source of supply or source for the conduct of research under this Agreement provided that such transfer shall be limited to that necessary to allow the firm or Institution to perform its approved role under this Agreement.

2. The Contractor shall provide timely notice to the Government of any proposed transfers from the Contractor of technology developed with Government funding under this Agreement to Foreign Firms or Institutions. If the Government determines that the transfer may have adverse consequences to the national security interests of the United States, the Contractor, its vendors, and the Government shall jointly endeavor to find alternatives to the proposed transfer which obviate or mitigate potential adverse consequences of the transfer but which provide equivalent benefits to the Contractor.

3. In any event, the Contractor shall provide written notice to the DARPA Program Manager and Agreements Administrator of any proposed transfer to a foreign firm or institution at least sixty (60) calendar days prior to the proposed date of transfer. Such notice shall cite this Article and shall state specifically what is to be transferred and the general terms of the transfer. Within thirty (30) calendar days of receipt of the Contractor's written notification, the DARPA Agreements Administrator shall advise the Contractor whether it consents to the proposed transfer. In cases where the Government does not concur or sixty (60) calendar days after receipt and the Government provides no decision, the Contractor may utilize the procedures under Article VII, Disputes. No transfer shall take place until a decision is rendered.

4. Except as provided in subparagraph C.1 above and in the event the transfer of Technology to Foreign Firms or Institutions is approved by the Government, the Contractor shall (a) refund to the Government funds paid for the development of the Technology and (b) negotiate a license with the Government to the Technology under terms that are reasonable under the circumstances.

D. Lower Tier Agreements

The Contractor shall include this Article, suitably modified, in all subcontracts or lower tier Agreements, for experimental, developmental, or research work.

ARTICLE XI: CIVIL RIGHTS ACT

This Agreement is subject to the requirements of Title VI of the Civil Rights Act of 1964 as amended (42 U.S.C. 2000-d) relating to nondiscrimination in employment.

ARTICLE XII: ORDER OF PRECEDENCE

In the event of any inconsistency within this Agreement the inconsistency will be resolved by giving precedence in the following order: (1) The Agreement, (2) Attachments to the Agreement.

ARTICLE XIII: EXECUTION

This Agreement constitutes the entire agreement of the Parties and supersedes all prior and contemporaneous agreements, understandings, negotiations and discussions among the Parties, whether oral or written, with respect to the subject matter hereof. This Agreement may be revised only by written consent of the Contractor and the DARPA Agreements Officer. This Agreement, or modifications thereto, may be executed in counterparts each of which will be deemed as original, but all of which taken together shall constitute one and the same instrument.

ARTICLE XIV: GOVERNMENT FURNISHED EQUIPMENT PROPERTY, INFORMATION FACILITIES AND SERVICES

The government does not anticipate the need for any Government Furnished Equipment/Property/Information in the performance of this agreement.

The following Government Equipment property, information facilities, and services shall be provided upon the written approval of the cognizant contracting officers:

(Offeror will list all desired GFE, GFP, GFI, GFF, and GFS.)

The Contractor shall not be liable for loss or destruction of, or damage to, the Government property provided under this Agreement, except that which results from willful misconduct or lack of good faith on the part of the Contractor's managerial personnel.

ATTACHMENTS

ATTACHMENT 1	Task Description Document (TDD)
ATTACHMENT 2	Technology Assessment and Development Plan (TADP)
ATTACHMENT 3	Demonstration Master Schedule (DMS)

7 DARPA Agreements Authority and Section 845 of the 1994 National Defense Authorization Act

7.1 Agreements Authority and Section 845 Authorization Act

DARPA "Agreements authority" was enacted as section 251, Public Law 101-189, the FY 1990 National Defense Authorization Act (codified at 10 U.S.C. ß 2371) and is currently found in part of 10 U.S.C. ß 2371. Section 845 of the 1994 National Defense Authorizations Act allows DARPA, on a pilot basis to use non-procurement Agreements for purely military Research and Development and, prototype projects and technology demonstrations of hardware directly relevant to weapon systems.

The primary benefit of this authority is that DARPA can tailor the contracting process to each project rather than conforming to predetermined contracting rules. This authority should increase the efficiency of DARPA's limited resources. DARPA also hopes use of this authority will shorten development time for these projects and enhance affordability.

This Section 845 Authority allows DARPA to:

1) Use Agreements even if a procurement contract would be appropriate or feasible.
2) Execute projects with or without cost sharing.
3) Implement streamlined acquisition procedures (e.g., using Generally Accepted Accounting Practices in lieu of Government Cost Accounting Standards).
4) Focus on goals and objectives rather than acquisition regulations.

Commercial Agreement Participants benefit from:

1) Increased government flexibility in structuring these Agreements (e.g., flexibility on patent and intellectual property issues).
2) Being able to use commercial rather than government procedures for doing business.
3) Government funding with minimum government bureaucracy.

Both Groups Benefit in that:

1) Armed Services Procurement Act, CICA, FAR, DFARS, and all procurement system regulations are inapplicable.
2) Existing regulations, MILSPECS, directives may but need not be applied.

Section 803 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001.

In order to broaden the technology and industrial base available for meeting Department of Defense needs, conditions have been put forth on the use of Section 845 Other Transaction for Prototype authority by the recent enactment of the National Defense Authorization Act for Fiscal year 2001. Section 803 of the National Defense Authorization Act for FY2001 (Public Law 106-398) became law on 30 October 2000. Section 803 modifies our authority to use the Other Transactions for Prototypes. In summary, for proposals submitted under this solicitation there must be either at least one nontraditional defense contractor participating to a significant extent in the prototype project; or, if there is no nontraditional defense contractor participating to a significant extent, at least one of the following circumstances exists; at least one third of the total cost of the prototype project is to be paid with funds provided by parties to the transaction other than the Federal Government; or, the senior procurement executive determines that exceptional circumstances justify the use of a transaction that provides for innovative business arrangements or structures that would not be feasible or appropriate under a contract. The definition for a nontraditional defense contractor is contained in the attached language. There is no definition for "significant extent" as in a "nontraditional defense contractor participating to a significant extent in the prototype project." The Government has discretion in determining the level of "significant extent." Some factors may include:

a) criticality of the technology being contributed
b) role of the non-traditional defense contractor(s) in the design process
c) value of the effort being proposed in comparison to the potential cost share value requirement

Because the evaluation is subjective, it carries with it some risk to the proposing team that the Government will not recognize the value; therefore, offerors are requested to identify in their agreement addendum the applicable Section 803 condition with explanation, which qualified them to receive an 845 award.

The entire amendment to the Authorization Act is available for your convenience at <http://www.darpa.mil/cmo> under "Breaking News" and includes the definition of a nontraditional defense contractor.

8 Appendix

The documents listed below are only available for Government contractors. If you are not a Government contractor, DARPA has a "Potential Contractor Program". This program provides various levels of access to documentation produced by the defense community. If you are not currently a DoD contractor, contact:

Debra Amick, DARPA Technical Information Officer
DARPA, 3701 N. Fairfax Drive, Arlington, VA 22203-1714
(703) 526-4163, fax (703) 696-2207, damick@darpa.mil

8.1 MIPCC Technology Documents

Bibliography Pertaining to Mass Injection Pre-Compressor Cooling (MIPCC) Installation of a Turbojet Engine

The following is a bibliography of reports relevant to MIPCC installation to a turbojet engine. This bibliography is not exhaustive. It was assembled to introduce today's engineers to the scope of previous work documenting this topic. There are a significant number of supporting references that define the technological and intellectual foundation of this topic. Historically this technology has been referred to as Pre-Compressor Cooling (PCC) or Pre-Compressor Evaporative Cooling (PCEC). For the RASCAL program has coined the phase Mass Injection Pre-Compressor Cooling (MIPCC) in order to distinguish this pre-compressor cooling technique from techniques utilizing pre-compressor heat exchanger cooling. The phase "Mass Injection" rather then "Water Injection" is used since we are interested in the possible injection of liquid oxidizers like liquid air or liquid oxygen in addition to just water. The injection of these fluids will enable engines to achieve higher altitudes, as well as higher Mach numbers, then could be achieved with water injection alone.

1. Trout, A.M., "Theoretical Turbojet Thrust Augmentation by Evaporation of Water During Compression as Determined by use of Mollier Diagrams," NACA TN 2104, June 1950, 93R12197.

2. Wilcox, E.C., Trout, A.M. "Analysis of thrust augmentation of turbojet engines by water injection at compressor inlet including charts for calculating compression processes with water injection," NACA-TR-1006, NACA Lewis Flight Propulsion Laboratory, Jan 01, 1951, 93R21353.

3. Willens, D., "Liquid Injection on Turbojet Engines for High Speed Aircraft." Propulsion Research Report R-139. 25 February 1955, AD0140167.

4. "Phase II Summary Report on Turbojet Specific Airflow and Specific Thrust Study." WADC TR-55-202, April 1955, AD0089882.

5. Sohn, R. L. “Theoretical and Experimental Studies of Pre-Compressor Evaporative Cooling for Application to the Turbojet Engine in High Altitude Supersonic Flight.” Propulsion Research Corporation, WADC-TR-56-477, 31 August 1956, AD097262.

6. Beke, Andrew “Analytical investigation of the effect of water injection on supersonic turbojet-engine - inlet matching and thrust augmentation,” NACA-TN-3922, Jan 01, 1957, 93R14162.

7. Gillard, T.J., Tate, J.T., and Basham, D.V. “Investigation of Several Spraybar Configurations for Use with Evaporative Cooling in a Straight Duct,” AEDC-TN-57-51, December 1957, AD0144327.

8. King, P.G., Nygaard, R.C., “Mechanical Operating Experience with Three J-57-P-11 Turbojet Engines During a Pre-Compressor Spray Cooling Test in an Altitude Test Chamber,” AEDC-TN-57-70, February 1958, AD150076.

9. Edwards, Z.B., Neely, James, and Ward, T.R. “Investigation of the Effect of Pre-Compressor Evaporative Cooling on the Performance of a J57-P11 Turbojet Engine.” AEDC-TN-58-7, March 1958, AD152034.

10. Gillard, T.J., and Tate, J.T. “Investigation of two Spraybar Configurations for Use with Evaporative Cooling in a Full-Scale Bifurcated Aircraft-Type Inlet Duct.” AEDC-TN-58-10, March 1958, AD0152036.

11. Jones, W. L., Sivo, J. N., Wanhainen, J. P. “The effect of compressor-inlet water injection on engine and afterburner performance,” NACA-RM-E58D03B, Jul 22, 1958, 71N70228.

12. Neely, James, Ward, T.R., and Edwards, Z.B. “Investigation of the effect of Pre-Compressor Evaporative Cooling with Water on the Performance of a YJ75-P-3 Turbojet Engine.” AEDC-TN-58-40, August 1958, AD161042.

13. Tate, J.T. and Gillard, T.J. “Investigation of Evaporative Cooling System Using Water Injected in Full-Scale Aircraft-Type Inlet Ducts,” AEDC-TR-58-4, June 1958, AD0157140.

14. King, Percy G., NyGaard, R.C., “Mechanical Operating Experience with a YJ75-P-3 Turbojet Engine During a Pre-Compressor Cooling Test in an Altitude Test Chamber.” AEDC, 01 Jul 1958, AD161039.

15. Neely, James, Ward, T.R. “Maximum Power Performance of a J57 and a YJ75 Turbojet engine with Pre-Compressor Water Evaporative Cooling, AEDC-TR-58-18, February 1959, AD-304817.

16. King, L.D., “Design and Testing of a Pre-Compressor Cooling System for a High Speed Aircraft,”, Chase Vought Corporation, Vought Aeronautics Division, May 22, 1961, AD324250.

17. Henneberry, H.M, Snyder, C.A., “Analysis of Gas Turbine Engines Using Water and Oxygen Injection to Achieve High Mach Numbers and High Thrust,” NASA TM-106270, July 1993, 94N13143.

8.2 Payload Interface

Goals for the RASCAL Payload Interface

The RASCAL launch system should be designed to make everything related to it as simple as possible for its customer, the payload organization. Much of the cost of space access is in indirect expense to payload organizations of having to make their payloads compatible with constraints and environments from the launch vehicle. While direct cost—the amount the customer must pay to the launch-system provider—is always a driver in the design of a launch vehicle (LV), indirect cost to customers is seldom a consideration. Thus, environments in particular, along with the payload verification process, are whatever they turn out to be.

Payload constraints, environments, and verification processes can be made much less stringent through thoughtful consideration during LV design. We believe launch vehicles should be designed to deliver payloads to their proper orbits not only at low direct cost but also at low indirect cost.

We are aiming to make launch analogous to ground transportation: All the customer wants to do is get a spacecraft to its operating environment. To do that, a truck takes the spacecraft to the launch site, then a launch vehicle takes the spacecraft to orbit. There is very little that a payload organization must do to ensure its spacecraft will be compatible with the truck. Air-ride trailers are designed to isolate the payload from the vibration environment, which is induced by tires running over rough pavement and potholes. If the bed of the trailer were hard-mounted to the axles, ensuring a payload would not be damaged would require a verification process similar to that used for launch, including high-level vibration testing and coupled loads analysis with configuration-unique math models.

We recognize that launch is a more complex problem than ground transportation. Nevertheless, we believe the burden on payload organizations of design and verification for the launch environment can be greatly simplified. In addition, launch environments can be made less severe. The RASCAL concept is well suited to meeting these goals, as discussed below.

This paper presents objectives, targets, and requirements related to the RASCAL/payload interface. In addition to environments, subjects include payload characteristics, physical interface, payload integration, and payload separation system. Firm requirements use the word "shall," and goals use words such as "should."

8.2.1 Payload Physical Properties

The LV should be able to accommodate payloads having the properties listed in Table 8-1 Limitations on Physical Properties of RASCAL Payloads..

Table 8-1 Limitations on Physical Properties of RASCAL Payloads.

<table>
<tr><td>Property</td><td>Limit</td></tr>
<tr><td>Mass</td><td>100 kg or less</td></tr>
<tr><td>Static envelope</td><td>1.2 m diameter by 3 m length</td></tr>
<tr><td>Mass moments of inertia</td><td>Limited only by mass and static envelope</td></tr>
<tr><td>Center of gravity (c.g.):</td><td></td></tr>
<tr><td>Axial—distance from c.g. to interface plane</td><td>1.5 m or less</td></tr>
<tr><td>Lateral—distance from c.g. to the vector that is normal to the interface plane and that passes through the center of that interface</td><td>0.03 m or less</td></tr>
<tr><td>Fundamental frequency when rigidly mounted at LV interface:</td><td></td></tr>
<tr><td>Axial</td><td>50 Hz or greater</td></tr>
<tr><td>Lateral</td><td>40 Hz or greater</td></tr>
<tr><td>Torsional</td><td>50 Hz or greater</td></tr>
<tr><td colspan="2">Explanation:
• Mass—The mass shown is the limit for the total payload, including any needed upper stage.
• Static envelope—This is the physical space in which the payload must stay in the static, unloaded condition. The LV shall provide a dynamic envelope large enough to ensure a payload with the static envelope and fundamental frequencies given above will not make physical contact during launch with any part of the launch vehicle. The dynamic envelope should accommodate rigid-body deflections of the payload resulting from deformation of the mounting structure combined with the elastic deformation of the payload under maximum expected launch loads. We recognize that the envelope specified above is quite large for a payload limited to 100 kg, but some potential payloads may require it. Most payloads will be considerably smaller. We would like insight into the outcome of any trade studies showing the impact on the LV of accommodating such a large envelope and the effects on predicted payload accelerations.
• Mass moments of inertia—self explanatory.
• Center of gravity—These limits are arbitrary and are suggested as a starting point. If these values drive system complexity or cost, it is acceptable to derive reasonable alternatives that can be specified to payload organizations.
• Fundamental frequency—These values are also arbitrary and intended as reasonable lower limits for payloads up to 100 kg. They are suggested as a starting point for designing an LV</td></tr>
</table>

control system and meeting the environment objectives (Sec. 4). Reasonable alternatives are acceptable.

8.2.2 Payload Interface and Integration

The physical interface between RASCAL and its payloads should be as simple as possible. Provisions should be made at the launch site to enable all payload-specific integration and testing to be done separate from the LV. The goal here is to minimize the time that any payload ties up the reusable first stage or the launch pad.

8.2.3 Separation System

The LV shall provide a payload separation system. This system should introduce negligible shock to the payload. (See below)

8.2.4 Payload Environments and Verification

Before trying to understand what we are asking for in the way of reduced environments and simplified verification for payloads, consider the present situation with existing launch vehicles. Most LV user's guides provide *quasi-static loads* (rigid-body accelerations), a spectrum of sound pressure level for acoustics, random-vibration and sinusoidal-vibration environments to be introduced at the payload's mounting interface, and a shock spectrum describing the effects from pyrotechnics used for separation.

The quasi-static loads apply only for preliminary design of the payload structure. *Coupled loads analysis* is typically required to provide loads for detail design and final verification. In such analysis, responses to time-varying applied loads are predicted using finite-element models (FEMs) of the LV and the payload, which have been mathematically combined, or "coupled," to form a system-level model. This analysis is required because, when a payload is hard-mounted to the LV, the system's dynamic characteristics change in a way that is unique for each payload, which means the system will respond differently to the time-varying forces during launch.

Thus, predicting structural loads for a payload is an iterative process: As the payload design is modified, it's predicted mass and dynamic characteristics change, which means the dynamics of the coupled system would change.

Coupled loads analysis is normally done by the LV organization, paid for by the payload organization as part of the cost of launch. The analysis is complicated, encompassing many load cases and accounting for many variables. Including the time spent by the payload organization in developing and checking a suitable FEM and by the LV organization in coupling and checking models, the full loads process typically takes three to nine months.

Not only is the process costly, its duration limits the number of iterations, or loads cycles. Many programs commit to a structural design after just one loads cycle; some have elected to build flight hardware before the first loads cycle is completed. As a result, payload organizations often assume a great deal of risk that the structure they build will not be able to withstand the maximum expected flight loads.

Before launch, a *verification loads cycle* (VLC) is normally done to confirm the payload and LV structures are adequate. Relatively large payloads, which normally have modes of vibration at frequencies low enough to interact with the LV's high-mass modes, require test-verified models for the verification loads cycle. To generate such a model, the payload organization first must conduct an expensive *modal survey test*, individually exciting and monitoring the key modes of vibration. Because predicted loads can be quite sensitive to small changes in FEMs, the VLC often produces loads in some parts of the payload that exceed the loads used for design and test. Costly redesign and retesting results. Payload organizations try to protect against such surprises by multiplying the loads predicted from previous cycles by a model uncertainty factor. But such a factor drives payload weight, and it often is not high enough to prevent problems at VLC.

Most small payloads of the RASCAL class have natural frequencies above the range of concern for dynamic coupling, so test-verified models of such payloads are usually not required. However, given the capability and cost of most existing LVs, a RASCAL-class payload is not the only payload. Instead, it's included as a secondary payload for a launch of a much larger payload, or it's one of many small payloads. In either case, the system-level configuration is unique and thus requires a VLC. So the predicted loads even for a small payload can increase after that payload has been designed, built, and tested.
RASCAL is intended for small payloads only. It's reasonable to assume that, for payloads with relatively high natural frequencies, RASCAL can be designed to ensure payload-unique coupled loads analysis is not needed. In other words, if time-varying forces are made less severe through engine design, or if a loads-isolating mounting system is developed, quasi-static loads at reasonably low levels should be sufficient for design and verification of payload structures.

We are challenging would-be contractors to design a launch system that will provide a soft, predictable ride for payloads. The objectives listed below apply the full time the payload is attached to any part (stage) of the launch vehicle:

- Reduce structural loading from the levels that are typical of other launch vehicles for small payloads. This includes loading to the primary structure and also the high-frequency vibration and shock that is potentially damaging to electronics, valves, and other small components.
- Make loads more predictable and insensitive to the payload design itself. If this objective is met, dynamic coupling between payload and launch vehicle will be either nonexistent or insignificant, and thus coupled loads analysis will not be needed.
- Simplify payload design and verification for launch environments.

Launch environments for the payload should be fully enveloped by the following environments to be specified by the LV organization:

- Quasi-static loads (translational accelerations only; see 8.2.4.1 Quasi-Static Loads)
- Acceleration power spectral density (PSD) for random vibration, applicable only to small components of the payload, such as electronics modules, not to the payload's primary structure (see 8.2.4.2 Acoustics and Random Vibration)
- A spectrum of sound pressure level (should be at insignificant levels for most payloads; see8.2.4.2 Acoustics and Random Vibration)
- A time history of cabin pressure
- Temperature extremes (should be insignificant for most payloads)

Not all of these environments need be specified, but no additional environments should be needed to envelop the effects on the payload from launch. We expect RASCAL to be designed to provide negligible shock to the payload. Shock testing is difficult and expensive for payloads, and the effects of shock cannot be predicted reliably enough to support payload design. "Shockless" separation systems, such as those that do not use explosives, are in use in the space industry and should be investigated so that negligible shock is introduced to the payload.

All mention below of "maximum expected" environments, loads, or stresses refer to levels for which there is no more than 1% probability of exceeding, at 50% statistical confidence.

8.2.4.1 Quasi-Static Loads

Table 8-2 Payload Rigid-Body Accelerations for Existing Launch Vehicles. **Units: g. These loads are intended for preliminary design only. Angular accelerations may also apply. (Source: launch-vehicle user's guides)** provides quasi-static accelerations that are typical for relatively large payloads aboard several existing launch vehicles. As payload mass drops, though, expected loading for payloads of existing LVs increases as a result of vibration. The energy in a vibrating launch vehicle is limited, so low-mass payloads accelerate more than high-mass ones when hard-mounted to the vibrating launch vehicle.

Table 8-2 Payload Rigid-Body Accelerations for Existing Launch Vehicles. Units: g. These loads are intended for preliminary design only. Angular accelerations may also apply. (Source: launch-vehicle user's guides)

Direction	Atlas II	Delta (all)	Space Shuttle	Titan IV
Axial	6.0	6.3	3.2	6.0
Lateral	2.0	2.0	2.5	2.5

Figure 8-1 Upper-Bound Payload Acceleration versus Mass. These curves are intended to represent upper bounds on acceleration, based on flight and test data. (Ref. Trubert, 1989.) shows JPL's empirically derived mass/acceleration curves, which indicate this trend. From this chart, we can see that a 50-kg payload (RASCAL class) might have up to about 17-g peak acceleration during launch on the Space Shuttle. Such acceleration would be from the combined effects of quasi-static LV acceleration, transient loading, and random vibration.

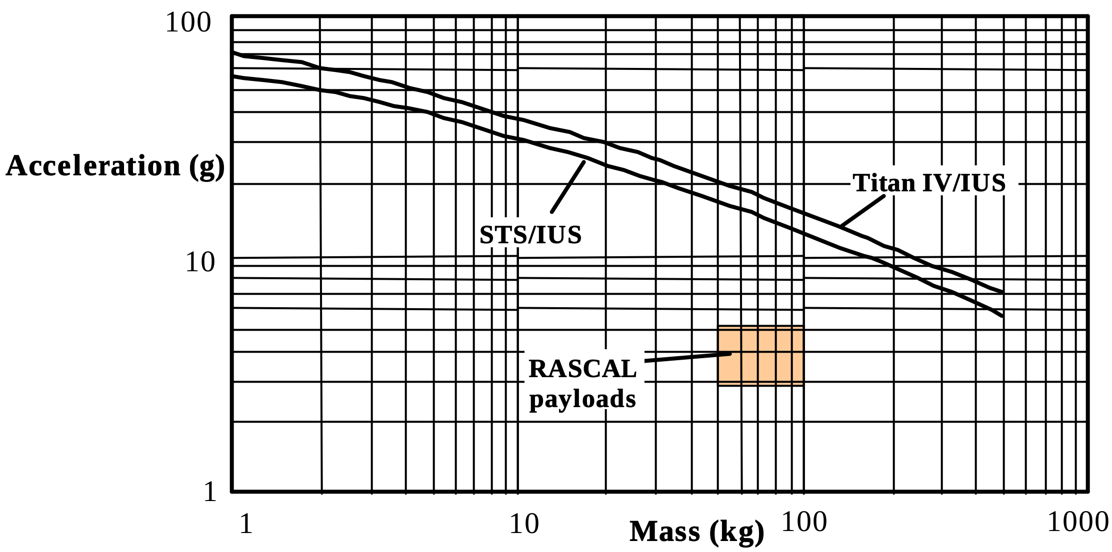

Figure 8-1 Upper-Bound Payload Acceleration versus Mass. These curves are intended to represent upper bounds on acceleration, based on flight and test data. (Ref. Trubert, 1989.)

To understand how severe the specified launch environment can be for small payloads—and how complicated the structural verification process can be, even without coupled loads analysis—consider NASA/Goddard's Hitchhiker program. Shuttle payloads flying under this program typically are small, in the RASCAL class. NASA/GSFC 740-SPEC-008 [1999], the specification for Hitchhiker payloads, defines rigid-body accelerations for the payload of 11 g in each axis acting simultaneously, combined with 85 rad/s^2 angular acceleration about each axis, also acting simultaneously. Such loading is not only severe, penalizing the payload in terms of structural mass and risk, it's also difficult to assess and to duplicate in a test. According to the specification, each of the six components of acceleration can act plus or minus, so the payload organization must assess a total of 64 (2^6) load cases.

An easy way to verify structural strength for a small payload is to mount it on an electrodynamic shaker and do a sine-burst test. In such a test, the shaker introduces sinusoidal acceleration at a frequency well below the payload's natural frequencies of vibration. As a result, the payload's modes of vibration are not excited, and the payload accelerates uniformly with the shaker. Such tests are often done in each of three orthogonal axes.

For three such tests to be adequate for a Hitchhiker payload, the payload organization must analytically derive a set of three uni-axial load cases that would stress the structure at least as much as the specified set of 64 load cases. This derivation depends on the geometry of the payload structure. As an example, the FalconSat-2 program at the United States Air Force Academy concluded that, for their payload, three orthogonal cases of 25 g acceleration (including a small uncertainty factor), separately applied, would envelop the specified Hitchhiker loads. 25 g is a lot of acceleration, and designing for it leads to a heavy structure!

RASCAL should be designed to ensure the maximum expected rigid-body payload accelerations, including the effects of steady-state and transient loads, are relatively low and independent of the payload's physical characteristics. Suggested targets are

- 5 g axial
- 2 g lateral

These values are reasonable when compared with the quasi-static loads shown in Table 2 for existing LVs. To ensure such accelerations envelop the state of loading for the payload structure, RASCAL must be designed to ensure the payload's high-mass modes of vibration are not significantly excited during launch. This can be accomplished through a loads-isolation mounting system, engine design, or perhaps other means.

The quasi-static loads specified to customers should cause stresses in the payload's primary structure that are at least as high as the maximum expected stresses during launch. The goal is for people to design a payload with confidence that the quasi-static loads represent a worst-case condition for its primary structure, enveloping the combined effects of actual steady-state acceleration, transient loading, and random vibration.

We are asking that rigid-body, rotational acceleration (typically in rad/s^2) not be specified because, from our experience, many developers of small payloads do not know how to assess rotational accelerations and thus ignore them. To keep things simple for payload organizations, the potential effects of any rigid-body, rotational accelerations expected to occur in flight should be included in the derivation of the quasi-static translational accelerations. Because RASCAL payloads will be relatively small, it should not be too difficult for the LV organization to identify simple load cases of rigid-body translational accelerations that would stress the payload's primary structure at least as much as the maximum expected flight loads.

Although payload organizations can deal with load cases consisting of rigid-body accelerations acting simultaneously in three orthogonal axes, it's easier to test a small payload for acceleration in each of three axes separately, as discussed above. Three load cases of single-axis accelerations can be determined to envelop launch loading, but they no doubt would overstress some areas of the structure. Some customers may prefer designing and testing their payloads to single-axis load cases, whereas others may prefer to minimize mass by designing and testing to more realistic loads. Not all customers will have the experience necessary to reduce specified three-axis load cases down to equivalent single-axis cases. Thus, we are asking the LV developer to do this for a bounding range of payload geometry and mass properties and then specify single-axis loads as an option. As a goal for ensuring a soft ride, the specified limit rigid-body acceleration should be no greater than 8 g acting in any direction.

One possible way to meet the above goals is through use of a loads-isolating mounting system for the payload. Such a system probably would require soft springs and high damping, as is the case with ground-vehicle suspension systems. If such a system is used,

- the LV control system must be designed not to respond to low-frequency, highly damped vibration of the payload moving as a rigid body on the soft springs, and
- enough clearance must be provided to ensure the payload, moving on the soft springs, does not make contact with any part of the launch vehicle.

The 1.2-m by 3-m static envelope defined in the second column of Table 1 is quite large for payloads limited to 100 kg. Most payloads under 100 kg would be considerably smaller so, by designing the LV to accommodate the larger envelope, there will be plenty of clearance to make loads isolation feasible for most payloads. It is acceptable to propose a design that effectively isolates only payloads that are smaller than the envelope defined in Table 1. It is also acceptable to require ballast for low-mass payloads to be assured of a soft ride.

8.2.4.2 Acoustics and Random Vibration

Because of the RASCAL concept, the acoustic environment for payloads should be quite low. The first stage will have air-breathing engines, which should not generate nearly as much noise as rocket engines, and the reusable vehicle should be much more aerodynamic than a typical launch vehicle. The second and third stages, which will use rocket engines, will be deployed above the atmosphere. Thus, the LV should be designed to ensure the acoustic environment is negligible for design and verification of typical payloads. The acoustic environment should still be defined, though, even if it's low, because someone could design a payload that is extremely sensitive to acoustics. The LV organization should provide guidance to customers regarding when acoustic testing should be considered.

Because random vibration is so closely related to acoustics, random vibration should also be a non-driver for payload structures. Random-vibration testing (and sine-vibe testing as well) should not be expected at the full spacecraft level of assembly. Doing such tests at high levels of assembly presents a difficult challenge in that, without notching or force limiting, primary structures are stressed much more severely than they will be during launch. *Notching* is a strategy for avoiding an overtest by reducing the input (typically acceleration power spectral density) in a frequency range corresponding to the fundamental frequency of the test article. *Force limiting* effectively does the same thing by controlling force introduced to the test article in addition to the shaker's acceleration. Such strategies are justified because energy is limited in a mounting structure that is randomly vibrating in response to acoustics, whereas, for an electrodynamic shaker, the energy is virtually unlimited. As a result, without notching or force limiting, a payload's high-mass natural frequencies respond much more in a base-driven test than they would in an acoustic test or during flight. Unfortunately, justifying and implementing specific levels for notching or force-limiting is costly and beyond the capability of many payload developers. Thus, most small spacecraft are subjected to unrealistically severe loading during random-vibration testing, with the result being unnecessary fatigue damage and possible failure.

The LV should be designed to ensure the maximum expected stresses in the payload's primary structure during launch will not exceed those caused by the specified quasi-static loads (8.2.4.1 Quasi-Static Loads). Specified random-vibration environments should apply only to smaller levels of assembly, such as electronics modules and PC boards.

Many small-spacecraft developers, though, may prefer testing for random vibration at the spacecraft level of assembly while set up to do sine-burst testing. Even at low levels of random-vibration testing, the primary structure for a relatively large assembly such as a 50-kg spacecraft can be overstressed. A relatively simple strategy for a payload developer to preclude overtest, if it can be justified, is to notch the specified environment to ensure the 3-? response acceleration of the fundamental vibration mode does not exceed the specified quasi-static acceleration (8.2.4.1 Quasi-Static Loads). Rather than expect the payload organization to justify this approach, the LV organization should do so through LV design and through sensitivity analysis that covers the expected ranges of mass properties and fundamental frequencies for RASCAL payloads.

8.2.4.3 Justification for Specified Environments

When requested by DARPA or by a customer payload organization, the LV organization shall provide adequate justification (supporting analyses and test data) to show the specified environments will envelop the maximum expected launch environments for the payload. Declining to provide this information, whether based on an argument that it is proprietary or any other reason, will not be acceptable. Payload organizations have the right to become confident in the loads and environments they use for designing and testing their payloads.

References

NASA/GSFC 740-SPEC-008, 1999. "Customer Accommodations and Requirements Specification."

Trubert, Marc. November 1, 1989. JPL D-5882. "Mass Acceleration Curve for Spacecraft Structural Design."